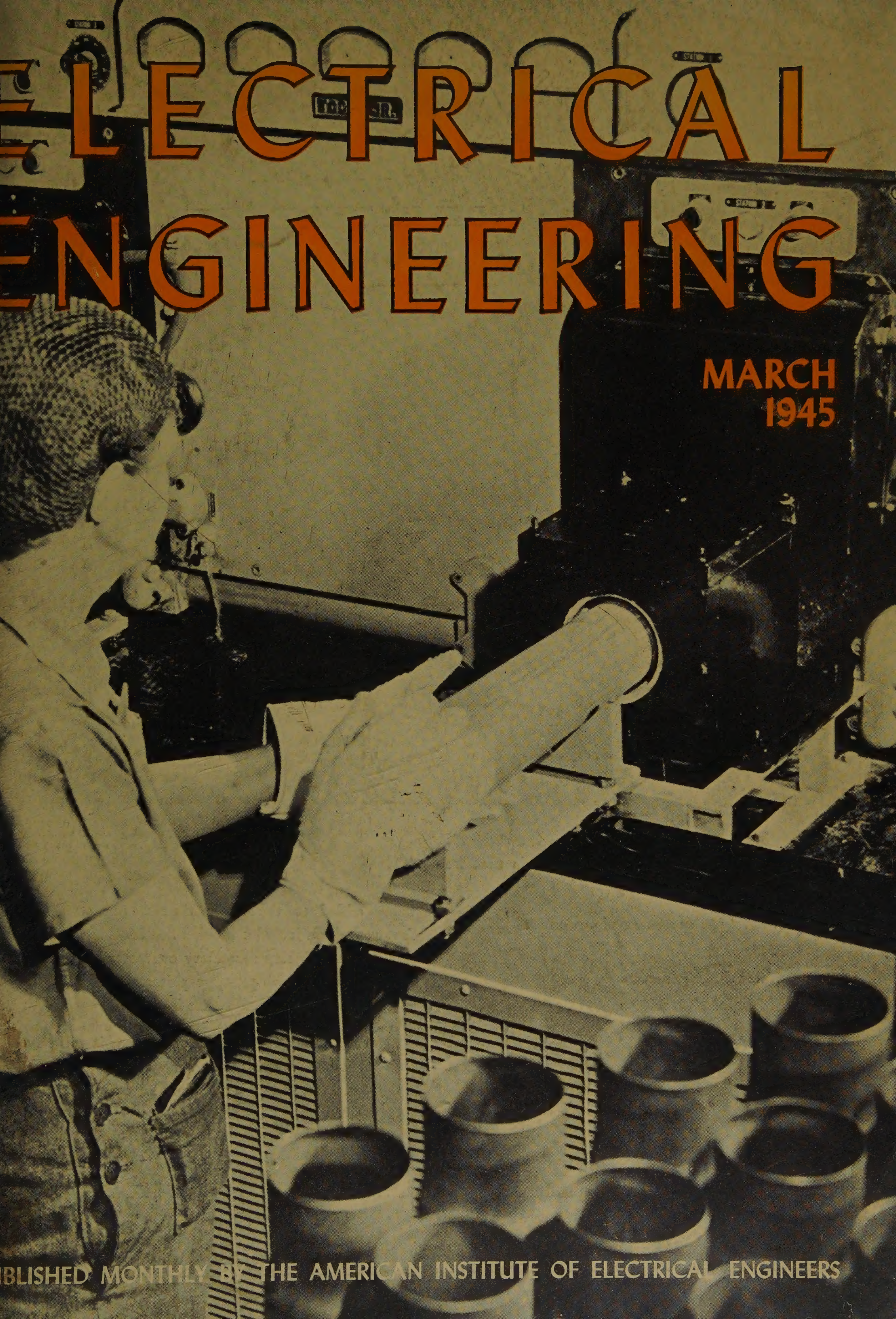
ELECTRICAL ENGINEERING

MARCH
1945



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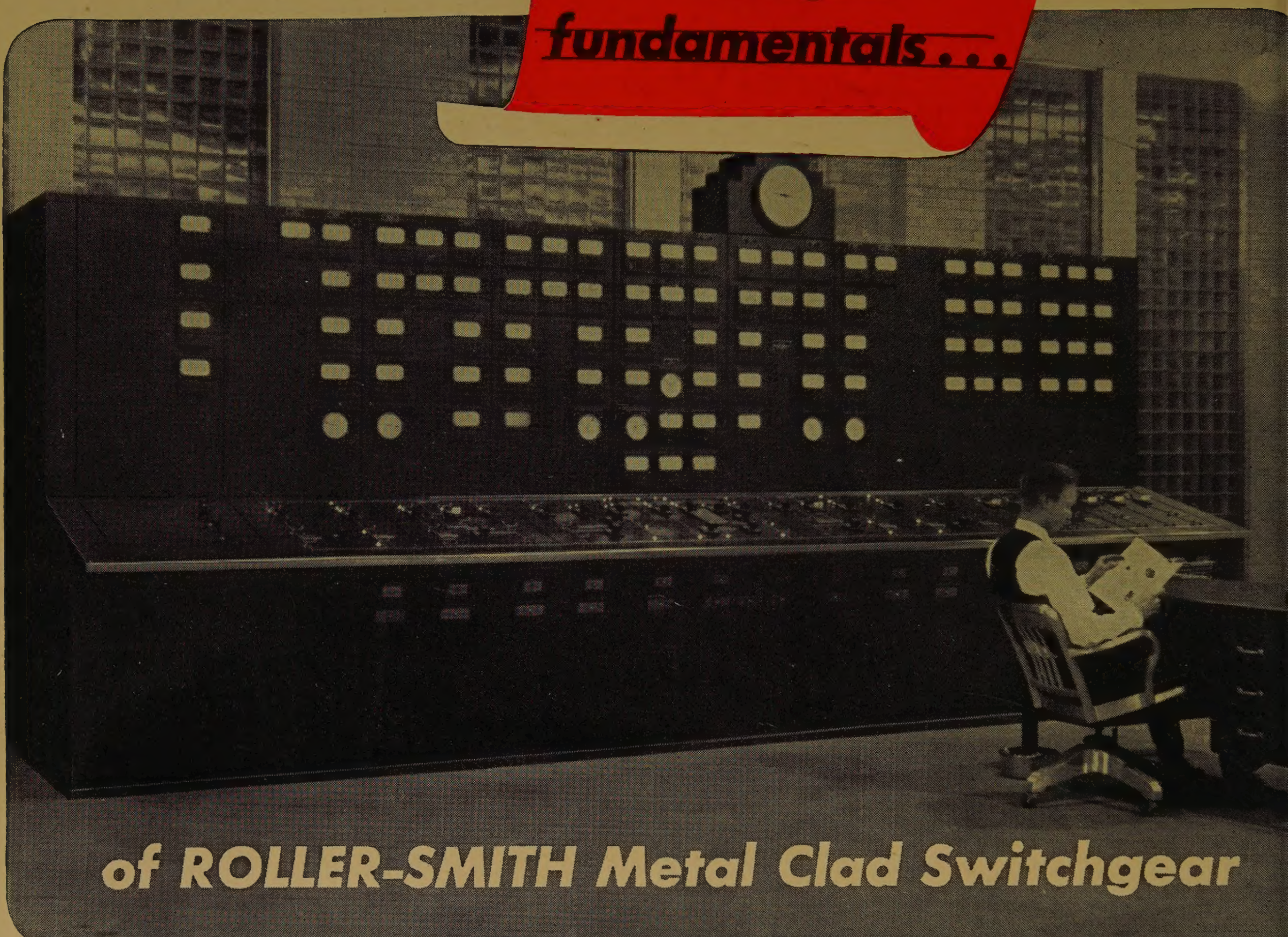
4 design fundamentals...



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ELECTRICAL ENGINEERING

Registered United States Patent Office

MARCH

1945

The Cover: High-frequency induction heating anneals the mouths of large steel cartridge cases to permit crimping onto shot or shell and to prevent splitting during use.

Photo courtesy The Ohio Crankshaft Company

The annual index for Volume 63, 1944, is now available; see page 120

TRANSACTIONS SECTION

(Follows EE page 132; a preprint of pages 87–150 of the 1945 volume)

Statements and opinions given in articles and papers appearing in *Electrical Engineering* are the expressions of contributors, for which the Institute assumes no responsibility. ¶ Correspondence is invited on all controversial matters.

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Some Navy Electronics Problems and a Proposal for a Radar Patent Pool

J. B. DOW

A proposal that $25,000,000 a year be set aside for a peacetime electronic research and development program for the Navy, a statement of the necessity of more thoroughgoing and extensive standardization of component parts, and a suggestion for a radar patent pool to solve the postwar radar problem are the high lights of this article.

ELECTRONICS is playing a leading role in the present great war in which substantially the entire world is engaged. Because it is the newest of the arts used in warfare on a great scale, because it has become the very heart of so many tools and weapons, and because its field of usefulness and the art itself are developing so fast, the outcome of the present war very well may be decided in favor of the nations which maintain the greatest lead in this field.

The Navy, the Army, and the Nation are depending upon the men and women of science and industry to maintain the lead which the United Nations now hold. From their minds and hands have come equipments and devices so important and so widely used that they take second place only to the personnel of our Armed Forces who utilize them; without these tools our forces would be at a hopeless disadvantage against enemies such as we are dealing with today.

The Navy always has recognized the importance of radio communication in the operation of ships and aircraft and for many years prior to the present conflict had been aware of the equally or more important part which other types of electronic equipment might play in a future war. The Navy continuously has sought equipment, components, and materials just a little better than industry thought at the time could be produced, and, when these materials were developed or produced, it almost invariably tightened its specifications or otherwise asked for more the next time. As a result of the co-operation, ingenuity, skill, and resources of science and industry, Navy communication equipment was well designed for the big job ahead at the time of our entrance into the war.

A long period of research and development by the Naval Research Laboratory with the assistance of the tube laboratories, and, later, the leading equipment manufacturers, had produced some very satisfactory types of radar, and by December 7, 1941, these were coming off the production lines in considerable numbers.

RESEARCH RELATED TO FUNDS

Much of what is done in research and development depends upon funds available for the purpose. Prior to the Navy fiscal year 1942 there was made available to the Naval Research Laboratory for electronic research and development an average annual sum of approximately $300,000 to cover the salaries of scientific personnel and project material. Funds for labor and the overhead connected with the laboratory were provided in addition to this. In 1942 this figure increased to approximately $600,000. For the fiscal year 1945 a figure of approximately $8,855,000 will have been reached.

While the Navy depends upon its own research and development facilities for much of this work—particularly where developments require the highest degree of security, or where by their nature, they are of little interest to commercial laboratories —at the same time much of the work is contracted to commercial electronic research and engineering organizations. The funds being spent during the fiscal year 1945 on such commercial contracts for research and development work will amount to approximately $38,000,000, exclusive of an estimated $25,000,000 being expended for development work under production contracts. These latter two figures total $63,000,000. The corresponding figure prior to the fiscal year 1942 was approximately $3,800,000.

Since the establishment of the Office of Scientific Research and Development, the Navy has drawn heavily upon the directly administered or contracted laboratory services of that office. In terms of dollars, the very substantial contribution of these laboratories to Navy research and development, probably would be at least equal to the $8,855,000 previously indicated for the Naval Research Laboratory with certain overhead and labor similarly not included. In the fiscal year 1945 a total of approximately $80,000,000 will have been contributed to Navy research and development in the electronic fields of radio, radar, and sonar, in comparison with a corresponding figure of roughly $3,800,000 prior to 1942.

The spread between these wartime and peacetime figures is so great that, even with full recognition of the fact that a war greatly accelerates the demand for research and development, the only sound conclusion which can be drawn is that we do not do enough such work in peacetime to prepare properly for war. When we emerge from the present world catastrophe, it is to be hoped that the need for an adequate peacetime research and development program will not be forgotten and that a minimum of $25,000,000 per year can be made available to the Navy for this work in the fields of radio, radar, and sonar.

A forward-looking, well-organized, and directed research program of adequate scope is admittedly costly, but it is nowhere near so costly in dollars and lives as a research program undertaken too late or after war begins, because following research comes the long design, development, and testing period necessary before new discoveries and modifications can be translated into terms of equipments installed and ready to use.

Intense wartime research, such as has been conducted by the Navy through the Naval Research Laboratory, the National Defense Research Committee, and a

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Essential substance of an address delivered at a joint session of AIEE and Institute of Radio Engineers, January 24, 1945, during the AIEE winter technical meeting, New York, N. Y.

Captain J. B. Dow is director, electronics division, Bureau of Ships, United States Navy, Washington, D. C.

great many commercial agencies, has advanced the art of electronics by many years. The bulk of electronic weapons which are now in large-scale production and use probably would not have been available in their present forms for another ten years without that intense research. However, many would have been available before December 7, 1941, had the importance of research and development been recognized to the extent which this war of science has taught us, and had funds been available to carry out vigorously a well-planned program.

To say that any nation is ahead of any other in a scientific art is likely to be misleading unless the comparison is based upon identical needs. Except in the case of submarines, Germany no longer has a navy of any considerable importance. Japan has one of considerable size, but it is not required to operate 8,000 miles from its prime supply sources and repair bases. From such observations as we have been able to make, it is safe to state that, from the Navy point of view, American science and industry have met our needs as well as the Germans have met theirs. We have good reason to believe these needs of our Navy have been considerably better met than the corresponding ones of Japan.

At the end of December 1941 the Navy comprised a total of 2,082 vessels and landing craft in each of which at least one transmitter and two receivers were installed. As of December 1, 1944, this figure had risen as a result of the shipbuilding program to 37,981. A large carrier has installed in it 101 complete equipments. A battleship has 78 such equipments. A small motor torpedo boat has seven. Certain of the smaller types of landing craft have as many as 13 complete equipments; others have as few as three. It is estimated that since December 7, 1941, some 300,000 complete equipments, each comprising two to 15 major units of equipment, have been installed in these 38,000 vessels and landing craft. Some idea of the complexity of these equipments can be gained when I say that they vary in cost from a few hundred dollars for a simple receiver to $250,000 for the most complex item. This installation task, accomplished by the Navy Yards, private shipbuilders, repair shipyards and other groups is one of the outstanding large-scale accomplishments of the war.

The program covering aircraft electronic equipment is equally worthy of note and in dollar value is almost identical with the ship program. In December 1941 the Navy had 5,200 service airplanes. By January 1, 1945, this figure had grown to be in excess of 38,000. These had to be equipped with transmitters, receivers, altimeters, direction finders, homing devices, radars, and other related equipment, varying from a minimum of three complete equipments for the smallest planes to ten in the case of the largest. The other programs involving equipment for the Marine Corps and shore and advanced base activities also are by no means small ones.

Delivery of electronic equipment under the administration of the electronics division, Bureau of Ships, has grown in dollar value from approximately $4,000,000 per month in 1941 to considerably over $100,000,000 per month in 1944. During the calendar year 1944 there was delivered to the Navy in excess of $1,300,000,000 worth of radio, radar, and sonar equipment, exclusive of a very large amount of equipment purchased directly from the Army.

CLIMATIC CONDITIONS SEVERE

The successful prosecution of the Navy's electronics program is contingent among other factors, upon the expeditious solution of many component-part problems. Navy electronic equipment is being used at present in every theater of war, where climatic and other conditions encountered are so severe that the establishment of simulating laboratory tests is an extremely difficult problem. A few of the general severe conditions are as follows:

High temperature combined with high humidity is encountered in countries such as Malaya, Burma, the East Indies, and the Philippines where the rainfall is constantly heavy on most days during the wet season. The air temperature may rise by day to 40 degrees centigrade and normally falls to about 25 degrees centigrade at night, but is never less than 20 degrees centigrade. Consequently, the relative humidity is very high and frequently reaches saturation for considerable periods.

High-temperature and low-humidity conditions prevail in many regions; air temperatures as high as 58 degrees centigrade occur during the day, and a drop to freezing occurs at night. The relative humidity in these regions may be as low as five per cent.

Subzero temperatures are encountered in Siberia, Alaska, northeastern Europe, and the northern parts of Canada. Temperatures as low as −40 degrees centigrade frequently are experienced. Temperatures of −55 degrees centigrade are relatively common, and −70 degrees centigrade may occur in isolated regions. Equipment generally is not required by specifications to work below −40 degrees centigrade, but must not suffer any permanent ill effects through transport or storage at the lowest temperature met.

Components may be exposed to an air pressure of 120 millimeters of mercury at an altitude of 42,000 feet. The rate of change of air pressure may be as high as ten millimeters of mercury per second. It should be remembered that equipment not designed for operation when air-borne may have to be transported by air freight at high altitudes.

Air temperature at 42,000 feet is reasonably constant at about −55 degrees centigrade. The rate of temperature change experienced by descending aircraft may be as high as five degrees centigrade per minute, but the actual rate of temperature change of apparatus will be lower, possibly two to thre degrees centigrade per minute.

Equipment is liable to suffer prolonge exposure to salt-laden atmosphere and spra from sea water.

Dust may be encountered as a cloud create a few feet above ground level by movin vehicles or as a dust storm created by stron winds which drive the particles to cor siderable heights and in all directions. Th dust particles may be abrasive or hygrc scopic.

In an atmosphere near saturation and othe favorable tropical conditions, fungus wi start to form within a few days. Man destructive insects also are encountered i jungle regions. The effects of fungi an insects are very serious and call for muc additional work on "tropicalization" c components and equipment.

All equipment must withstand withou serious reduction in performance or re liability severe mechanical vibration, shock and rough handling.

The experience gained in this war ha shown that a high percentage of thos components designed for domestic com mercial service cannot withstand the ex tremely severe climatic and other condi tions to which they are exposed, either ou of doors or under inadequate shelter durin shipment, storage, and operation, i forward areas. In addition, many re finements and advances in radio, radar and sonar design during the present wa have imposed heavier demands upon th component designers and manufacturer of smaller, lighter, and more dependabl types of components the need for whicl was not entirely realized even a few year ago. In many instances improvement in the designs of components have no kept pace with equipment advances consequently, the problem of improvin the usefulness, dependability, and ease o maintenance of equipment in the field i contingent largely upon improving th quality and performance of variou necessary components, rather than upo further refinements in the basic equipmen designs.

Improvement of the dependability o components is contingent largely upo more thoroughgoing and extensive quali fication testing of components themselve In many instances misapplication of com ponents with attendant high failur within equipment can be traced directl to the fact that the limitations of the com ponent with respect to electrical rating temperature, vibration, pressure, and s on, had never been accurately establishe for the guidance of the equipment-desig engineer. In this connection, the Nav is establishing at the Naval Researcl Laboratory a $1,000,000 component testing laboratory supplied with th necessary measuring apparatus and tech nical personnel to pursue an active an continuing program for the improvemen of components required in radio, rada and sonar equipments. It is intended tha

this activity shall be maintained in peacetime on a large scale in order that the types of components suitable for Naval usage can be ascertained and made the subject of continuous improvement. The present qualification testing of components, under joint Army–Navy standard specifications, is being done on an appreciable scale at this laboratory and will increase as additional types of components are covered by approved *JAN* specifications.

The actual work of joint standardization of components has been carried on for over $2^1/_2$ years by the Bureau of Ships and the Signal Corps, in collaboration with the American Standards Association, the War Production Board and representatives of industry, and has resulted in about 40 published standard specifications with many more to follow in the future.

To facilitate better the work of component-part standardization the Army–Navy Electronics Standards Agency, now quite generally known by its brief title *ANESA*, was established in December 1943 and was given the responsibility and authority for co-ordinating electronic-equipment component specifications to be used by both services. After drafting, the co-ordinated specifications are processed independently by the Bureau of Ships and the Signal Corps through approved channels, and, after industry and WPB have offered comments for consideration, a final approved draft is submitted to the Joint Army and Navy Committee on Specifications for approval as a *JAN* specification.

Following issuance of the approved *JAN* specification, the laboratory facilities of the Signal Corps and of the Navy are pooled to carry out the qualification testing of components and materials submitted by prospective suppliers. Test reports resulting from qualification tests are reviewed by both services, regardless of which service laboratory conducted the tests. Following review of the test reports, independent action is taken by each service to establish listings of approved manufacturers of standard components and materials. Action at present is being taken to work out a procedure by which joint Army–Navy approval certificates can be issued.

It is believed that the following benefits to the Navy would result directly from standardization:

1. Replacement components in Navy yards and depots and in the field are more readily identified and, therefore, more readily usable among various types of Navy electronic equipments since the standard components can be identified by standard markings, nomenclature, color coding, and so forth. In this connection, a very major maintenance problem exists in the Navy at the present time, because the present nonstandardized systems of marking components do not permit relatively inexperienced personnel to identify usable substitutes or often even identical items supplied by the many equipment manufacturers.

2. The work load imposed on field maintenance personnel, especially those inexperienced in maintaining equipment is made less burdensome by virtue of the relatively smaller number of noninterchangeable components of each particular type which must be stocked, properly packed, housed, and correlated with the proper Navy electronic equipment.

3. The expanded use of standard components will minimize the vast numbers of components with respect to types, sizes, and ratings, which must be dealt with in regard to improvement, testing, inspection, procurement, stock upkeep, issue, and cataloging, and hence will reduce the man-hours required for preparing necessary drawings, specifications, stock catalog numbers, and other clerical work.

4. The co-ordination of production among the various plants of equipment and component manufacturers and control and scheduling of component deliveries to equipment manufacturers can be accomplished on a far better basis through the availability of standardized and co-ordinated components. During the past three years one of the most difficult problems has been that of co-ordinating the production of Navy electronics equipment among the many equipment prime contractors to make maximum use of facilities for the production of components, the availability of which too often has limited and seriously delayed the production of equipment. The magnitude of this problem can be appreciated when one realizes that some thousand different plants and laboratories have been working under Army or Navy contracts in supplying electronic components and equipment. Component standardization will go a long way toward the solution of problems resulting from this cause.

One difficulty in the standardization of components has been the disinclination of many engineers, both in the Government and in industry, to become involved in the tedious, detailed, and relatively uninteresting work associated with the preparation of standards, with the result that a heavy work load has been imposed on a restricted group. The responsibility for component standardization must be assumed by a greater number of engineers who have a combined knowledge of the needs of industry and the armed services and of standardizing procedures.

Another difficulty experienced in that phase of component standardization having to do with the establishment of performance requirements is the tendency on the part of a relatively small portion of industry to question and discount heavily the necessity for some of the stringent and detailed requirements stipulated by the armed services. The services are not in every case 100 per cent correct in asking for certain tight and detailed requirements. However, by virtue of living with and having the responsibility for correcting failures in the field under conditions in the field, the armed services do have knowledge of the need for special performance requirements.

STANDARDS EFFECTIVENESS REDUCED

In the past and even at present the advantages of standard *JAN* specifications are being vitiated by requests for waivers from the required tests. Such waivers in whatever form granted, and if allowed to increase in number, rapidly reduce the value of standard specifications to an ineffectual level. The effectiveness of any good standard is contingent largely upon all interested activities voluntarily making every effort toward its adoption and application as a desirable instrument to implement mass production and simplify maintenance problems. Requests for waivers should be made only in cases of the highest urgency.

The production of dependable and easily maintained equipments with the least component complexity is contingent greatly upon the early selection and application by the equipment-design engineer of standard approved items for the various required components during the conception, research, and development phases. Research personnel and development engineers working on the early stages of equipment development are far too prone to use non standard components in their early experiments, consequently, far too often the resulting mechanical and electrical problems left to the final design engineers are so formidable that many nonstandard components are left in the equipment as it is finally delivered, and thus the great benefits of component standardization are lost.

While the prime effort of component standardization must be directed toward the problems of immediate urgency in advancing the present and future activities of this global war, it is hoped that the component standardization achieved during the war will not be shelved in the postwar period but will be expanded and improved. The reorderings, delays, waste of material, waste of shipping and storage space, excessive purchases of spare parts, added costs, and many other undesirable conditions arising from the use of nonstandardized items, must be vastly reduced. Taken collectively, these undesirable conditions probably already have cost the Navy $100,000,000 in this war. What has been accomplished in standardization under war conditions will be lost again in the years of peace to follow unless industry continues to understand and give full support to the solution of the problems of the services.

Of considerable importance also is the postwar radar patent situation. This new and important art was born only a few years preceding this war, and probably 95 per cent of the so-called radar inventions upon which patent applications have been filed or are in process have been made since January 1, 1941. Because of

the restrictions which have been placed on the dissemination of information concerning radar developments, little information is available concerning the number, nature, and scope of patent applications on file and in process, except to a relatively few officers of the Government. A large number of inventions of importance to the production and use of well-designed radar equipments have been made the subject of patent applications. The United States patents resulting from these applications will be widely held in industry, by foreign interests, by individuals, and by the Government. It is expected that a considerable block of radar patents, now held in a secret status in the form of applications in the Patent Office, will issue upon relaxation of the present security restrictions following the war.

Pending a reasonable adjustment of the patent situation which may require as long as ten years, it is expected that the following undesirable conditions will exist unless appropriate steps are taken now to avoid them:

1. Contractors will not be able to supply the services and the public with the most suitable designs of radar equipment because of adversely held patents.

2. A pyramiding of royalty rates will contribute to excessive costs of equipment.

3. A great amount of litigation will follow the issuance of patents.

PATENT POOL MAY BE SOLUTION

To overcome these conditions, it is recommended that the electronics industry either establish a radar patent pool for a period of ten years following the war, or work out some other satisfactory solution to the problem. The services and the public are entitled to the best-designed equipment that the state of the technical art is capable of providing. Moreover, the Government will not long acquiesce to the payment of pyramided royalty rates which represent a substantial portion of the cost of equipment, especially since practically all of this development has resulted directly or indirectly from the expenditure of public funds.

In order to look at the picture in proper perspective it is desirable, first, to consider just what dollar value of business probably is involved. A figure of $75,000,000 per year for several years following the war is probably representative of the volume of sales in the United States for radar equipment for Government and commercial purposes. All equipment utilizing radar techniques is included in this estimate.

A suggested pool, operating as a corporation, might be financed initially by a Government loan and organized by all of the electronics industry. The corporate structure of such a pool conceivably would comprise a board of directors, a corporation president selected by the board of directors, and a patent department, legal department, and accounting department, together with such officer, staff, and other assistance as may be needed. Membership would be limited to companies, agencies, or individuals who contribute patents essential to the operation of the pool and would continue during the useful life of such patents.

The successful establishment and operation of such an agency would require the full co-operation of all holders of major blocks of pertinent patents. This co-operation would have to be extended to a degree which would enable the management to make the enterprise attractive to the many holders of small blocks of patents whose enrollment as members is mandatory if all the benefits of pool operations are to be obtained. Foreign holders of United States patents essential to radar, of which there may be a considerable number, also should be admitted to membership under conditions to be determined.

The corporation, insofar as practicable, would obtain licenses under all radar patents considered essential to the manufacture, sale, and use of radar; all non-radar patents essential to such manufacture, sale and use; and the right to grant sublicenses under such patents in that field.

If the past policies of the Government in patent matters are any criteria of the future, I believe that the Government would license the pool upon a royalty-free basis under its considerable block of pending radar patents but would wish to retain any voting rights given members.

The corporation itself should determine the essentiality of any patent to the pool's operation. For carrying out this responsibility, it is proposed that an essentiality board be set up within the patent department. Provision should be made to permit any patent holder to present his case to this board, and, if a satisfactory showing of use by any licensee of the pool is made, the corporation may accept such patent holder as a member of the pool. Decisions of courts favorable to patent holders in infringement suits against licensees of the corporation also should be accepted as a showing of essentiality if, in the opinion of this board, such decision applies to the radar art.

The license granted the corporation by a member should provide that all essential patents held or acquired by such member be made available to the pool. It is contemplated that each member may himself become a licensee of the corporation upon his own request. The corporation should grant licenses only on condition that such licensees holding or acquiring patents essential to the art will themselves become members of the pool. The proceeds from operations would be distributed to each pool member in proportion to the value of patent rights which he contributes.

Infringement suits between pool members and licensees should be nonexistent, since, if any member can make a satisfactory showing of use of a patented invention in radar equipment manufactured, sold, or used by a licensee, such patent is itself available to the corporation and to its licensees. The same applies in the case of suits by licensees against pool members and by licensees who may not be registered as members, in the case of suits by such licensees against other licensees of the corporation. Exceptions to these cases conceivably might arise should the corporation decline to recognize the essentiality of a patent.

It is thought desirable to establish a legal department of the corporation, independent of the patent department, to provide legal services at no cost to members and licensees upon request in bona-fide radar patent matters, such as infringement suits by patent holders who are not pool members or licensees. In extending such legal services it is contemplated that members or licensees may prosecute their cases with legal assistance of the corporation or may request the corporation to prosecute their cases with such assistance as the member or licensee may give. While these legal services may be provided at no cost to the member or licensee, it is contemplated that the member or licensee will pay any damages assessed by an adverse decision in such a suit.

Except in the case of a contest between a member or licensee and a nonmember, it would be undesirable for the corporation to render legal assistance or otherwise engage in radar patent matters involving validity. The articles covering the operation of the corporation should provide that it take all necessary legal action against infringers of pool patents. Since such actions will be against nonmembers and nonlicensees, matters involving validity in such cases may be engaged in by the corporation.

A uniform royalty of six per cent of the selling price of radar equipment should be paid to the corporation by all licensees. This would not be excessive from the point of view of licensees since, through the operation of a pool system, they will be relieved of the need of paying pyramided royalties. This figure would be adequate to provide a reasonable financial return to members of the pool since the pool system will have greatly reduced expenditures by members which otherwise would have to be made for legal services, license management, and defending infringement suits, especially in the case of those members who are themselves radar manufacturers.

DISTRIBUTION OF PROFITS

The matter of how to distribute among members the profit from operations presents the most difficult problem to be faced in the operation of such a pool. It

is proposed that the corporation place patents in the following classes with reference to extent of use:

Class 5—Used in more than 75 per cent of the equipments sold by licensees in the preceding year.

Class 4—Used in 50 to 75 per cent of the equipments sold.

Class 3—Used in 25 to 50 per cent of the equipments sold.

Class 2—Used in 10 to 25 per cent of the equipments sold.

Class 1—Used in less than 10 per cent of the equipments sold.

This use classification is to be made by a patent-classification board. A member may request reconsideration of the classification of any patent at any time, and, if in his opinion an injustice has been done, he should be entitled to a hearing before the board.

While the most widely used inventions are generally the more basic and important ones, certain inventions enjoying restricted use may be of the greatest importance in their particular field of application and may not be circumvented by any known means. To satisfy the need for this kind of distinction, it is proposed that a weight factor be assigned to each patent by the patent-classification board. Weight factors also would be subject to review upon the request of the pool member concerned in the same manner as use classifications. Weight factors of 1.00, 1.25, 1.50, 1.75, and 2.0 are suggested. Except in the case of a small percentage of the patents, the largest weight factors will be associated with those patents having the highest use classification.

An alternate method to that just proposed might be used to simplify the work and profit distribution of the corporation. Radio Corporation of America, American Telephone and Telegraph Company, General Electric Company, and Westinghouse Electric and Manufacturing Company together probably would control about one half or perhaps more of the essential patents. It might be possible to reach an agreement with all the members whereby three per cent of the profits each year would be turned over to the foregoing group of major companies for distribution among themselves and the remaining three per cent distributed by the method previously mentioned. This alternate method would make it unnecessary to consider anything but essentiality in the case of patents held by these major companies to determine the equitable division of the three per cent of profits, and perhaps even this might be made unnecessary by agreement among members of the pool.

What will be the final solution to the radar patent situation cannot be forecast at the present time, but the matter is one which merits industry's full attention.

Navy's Electronics a Global Job

The installation and maintenance of radio, radar, and sonar equipment throughout the United States' fleets, on Marine amphibious vehicles, for naval air units, in permanent land stations, and for the more transitory faraway stations, which move with the fluid perimeters of the battle areas, are engineered from the electronics division of the United States Navy's Bureau of Ships. The installation and maintenance branch of the division in Washington, D. C., under Commander H. E. Bernstein does all the necessary planning and staff work.

When new equipment is to be installed on a certain class of ship, a careful study of the effect of the added weight on the stability of the ship as a whole must be made. The locations of the delicate equipment must be checked for possible interference or damage from other equipment, heavy guns, or exposure. Locations for antennas, for example, must be studied from a stability and interference standpoint. The first installations are observed closely so that the benefit of experience may be applied to later installations. After the equipment has been turned over to a Navy yard for installation the electronics division dispatches engineers, who are manufacturers' employees, to advise the yards in the use and handling of their products.

In addition, the electronics division has recruited a flying squadron of specially trained Navy technicians organized as the electronic field service group. These technicians are assigned primarily to absorb the impact of new programs or projects which would place too great a load on the normal facilities of the Navy yards and other installing agencies and to handle other emergency work. A picked group of these technicians travels with the fleet wherever it goes, transferring from ship to ship as the exigencies of the current situation demand. These men are trained in the installation and maintenance of the latest type of equipments and therefore are able to render prompt and able assistance to ship forces in solving their problems.

Maintaining air stations both for operation and training has become a major task of the division with the rapid expansion of the Navy's air arm. This shore activity alone is larger than the combined operations of all the commercial air fleets now extant in the majority of the Allied countries.

For the Marine Corps the electronics division is charged with installation and maintenance of its amphibious vehicles, its advance radio stations, and its control centers. Thousands of walkie-talkie sets and like equipment used by the Marines also are its responsibility. All communication equipment used between shore patrols and military police jeeps come under its jurisdiction.

The function of the electronics division in the maintenance of fleet electronic equipment involves four major activities. First is the direction of normal day-to-day maintenance by technicians aboard ship. Analysis of thousands of trouble reports each month gives a clue to types of preventive maintenance which will insure dependable operation at all times. Maintenance bulletins containing valuable information on preventive maintenance and trouble shooting are prepared by the division's engineers and distributed frequently to all naval activities.

Next is liaison with all schools engaged in training naval personnel in the installation and maintenance of electronic equipment used in the Navy. This liaison work includes advising training schools on the technical aspects of their curricula and supplying them with adequate amounts of the latest equipment.

Assisting repair facilities such as Navy yards as required in the emergency of repairing or replacing battle-damaged equipment is a third activity. Finally, many additional publications dealing with special installation and maintenance problems are prepared by the electronics division's engineers. These publications are aimed at improving the performance of radio, radar, and sonar equipment so that the fleet and naval establishment will have available, at all times, dependable up-to-the-minute electronic equipment.

In all, the electronics division of the Bureau of Ships is co-ordinating the efforts of approximately 75,000 workers, who have already installed almost $2,000,000,000 worth of electronic equipment and who are performing efficiently in the maintenance of this vast amount of apparatus.

Grounding Principles and Practice

III—Generator-Neutral Grounding Devices

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Characteristics of devices for grounding the neutrals of synchronous generators and the conditions under which the various types of devices are used and their effect on associated equipment are discussed in this article, the third in a series of five based on lectures which were sponsored by the power and industrial group of the AIEE New York Section during the 1943–44 season.

WHAT determines the desired characteristics of a generator neutral-grounding device? Under what conditions is each type of device best suited? How does the grounding device affect other generator protective equipment? Why do system characteristics have to be considered? These and other questions regarding the grounding of synchronous generators have been asked many times; this article provides many of the answers and attempts to present a practical solution of most application questions concerning usual neutral-grounding devices.

In the grounding of a generator, theoretical considerations, as well as experience and operating records, should be given considerable weight. A generator is a highly insulated, rugged piece of equipment, and a failure on a particular unit or its connecting leads, though possible, is not expected. To guard against this possibility of failure, protective relays are installed, phase-to-ground winding fault currents are limited to safe values, lightning-surge equipment is applied, and other precautions are taken.

In the event of a generator-winding or terminal-lead failure caused by excessive transient voltages, the method of grounding may appear to be absolved on the basis of available fault evidence. It is entirely possible, however, that the insulation might have been damaged and weakened at some time previous to the final insulation breakdown. This could be caused by an arcing ground on the generator terminals or by arcing between the generator-circuit-breaker contacts when the breaker operates. Thus the method of grounding should be scrutinized carefully to determine whether it might cause damaging overvoltages under any conditions.

The usual types of devices for grounding generator neutrals are:

1. Reactor (usually a low-ohm device).
2. Resistor (to limit current to about 1.5 times normal of generator, or less).
3. Small power (or distribution) transformer with resistor across its secondary.
4. Potential transformer or combination of several potential transformers.
5. Infinite impedance (neutral ungrounded).

REACTOR

In determining the reactor size, a single-phase-to-ground fault is assumed at the generator terminals. The object is to limit the fault current in the winding to that value which would result from a three-phase fault. Three-phase fault current is determined by using rated line-to-neutral voltage of the generator and its positive-sequence (subtransient) reactance. In determining the single-phase-to-ground short-circuit current, the positive-, negative-, and zero-sequence reactances must be known for the generator under consideration and for the system. These sequence reactances, X_1 (positive), X_2 (negative), and X_0 (zero) are usually given for new generators and can almost always be obtained for old machines from the manufacturer.

The following nomenclature will be used:

X_1, X_2, X_0 = sequence reactances of generator under consideration

S_1, S_2, S_0 = sequence reactances of system to terminals of generator under consideration including everything except generator being studied

X_R = reactance of neutral reactor

I_R = maximum rms current rating of reactor (in designing the reactor for mechanical strength it is assumed that the current is fully displaced due to d-c component)

Determination of X_R and I_R in Per Cent. Single-phase-to-ground faults have been classified into five groups in Figure 1 depending upon generator and system reactances. Group 1 is general and covers the case where all generator and system reactances are finite and different. This formula is formidable in appearance but it simplifies rapidly with actual values. Group 2 covers the case where system zero sequence is infinite and all other reactances are finite and different. Groups 3, 4, and 5 cover cases where two or more reactance values are equal; consequently, the formulas are considerably simplified as compared to the general case in group 1.

The formula for I_R in each case is for X_R of such a value as to make the machine-winding current on a single-phase-to-ground fault equal to the winding current on a three-phase fault. The voltage e in the formula for I_R is the rated generator terminal voltage expressed as 100 per cent. It should be pointed out that whenever X_1 and X_2 of a generator are equal, the minimum reactor reactance $X_R = (X_1 - X_0)/3$. This is true regardless of the system. The current through the reactor on single-phase-to-ground fault, however, depends on system reactance as well as generator reactances.

Turbogenerator Neutral Reactors. Figure 2 shows neutral-reactor currents given by the formulas of groups 4 and 5, Figure 1, and apply particularly to turbogenerators. They are plotted in terms of ratios; the ordinate is the ratio S_1/X_1 and the abscissa K is the number of times three-phase fault current e/X_1 which will flow through the neutral reactor. For each of the five curves the ratio S_2/S_1 is a parameter. The curves show at a glance the effect of system reactance on the neutral current during a single-phase-to-ground fault and also that S_1 and S_2 may be far from equal without appreciably affecting the neutral current I_R. The reactance of the grounding reactor is determined by the formula $X_R = (X_1 - X_0)/3$. To determine the maximum rms current I_R through the reactor determine S_2/S_1 and S_1/X_1 and find K from Figure 2. The current I_R equals $(K)(e/X_1)$ in per unit. Multiply per unit by 100 to get I_R in per cent.

Discussion. The reactance and current values for the neutral reactor must be checked for each system condition. A reactor which will protect the generator for all operating conditions must be applied. An example would be the application of a neutral reactor to a generator which at times is the only ground and at other times is operating in parallel with a grounding transformer. The reactor should also be checked with the generator operating as an isolated machine.

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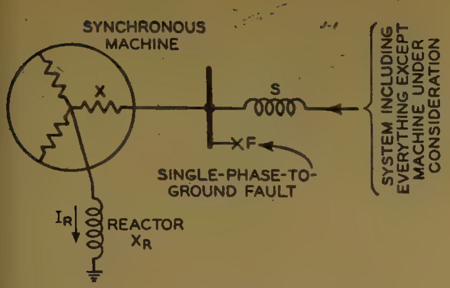

Figure 1. Determination of reactor characteristics

The reactance and current values for neutral grounding reactors under different conditions can be determined as follows, when the winding fault current for a single-phase-to-ground fault is made equal to the three-phase fault current:

Group 1—All reactance values finite and different

$$X_R = \frac{S_0(X_1X_2+2X_1S_2-X_2S_2)+X_0(X_1S_2-X_2S_2-X_2S_0-S_0S_2)}{3(X_2S_0+X_2S_2-X_1S_2+S_0S_2)}$$

$$I_R = \frac{3S_0}{X_0+S_0+3X_R}\times\left(\frac{e(100)}{\dfrac{X_1S_1}{X_1+S_1}+\dfrac{X_2S_2}{X_2+S_2}+\dfrac{S_0(X_0+3X_R)}{X_0+S_0+3X_R}}\right)$$

Group 2—S_0 = infinite; others finite and different

$$X_R = \frac{X_1-X_0}{3}+\frac{S_2(X_1-X_2)}{3(X_2+S_2)}$$

$$I_R = \frac{3e(100)}{\dfrac{X_1S_1}{X_1+S_1}+\dfrac{X_2S_2}{X_2+S_2}+X_0+3X_R}$$

Group 3—$X_1=X_2$; others finite and different

$$X_R = \frac{X_1-X_0}{3}$$

$$I_R = \frac{3S_0e(100)}{(X_1+S_0)X_1}\left(\frac{1}{\dfrac{S_1}{X_1+S_1}+\dfrac{S_2}{X_1+S_2}+\dfrac{S_0}{X_1+S_0}}\right)$$

Group 4—$X_1=X_2$; S_0 = infinite; others finite and different

$$X_R = \frac{X_1-X_0}{3}$$

$$I_R = \frac{3e(100)}{X_1}\left(\frac{1}{\dfrac{S_1}{X_1+S_1}+\dfrac{S_2}{X_1+S_2}+1}\right)$$

Group 5—$X_1=X_2$; $S_1=S_2$; X_0 = finite; S_0 = infinite

$$X_R = \frac{X_1-X_0}{3}$$

$$I_R = \frac{3e(100)}{X_1}\left(\frac{X_1+S_1}{X_1+3S_1}\right)$$

The value of X_R, as just determined, makes the generator winding current on a single-phase-to-ground fault equal to the winding current on a three-phase fault. The reactance may be larger than this further to limit the fault current, but it should not be increased without considering its effect on transient voltages during switching operations and arcing

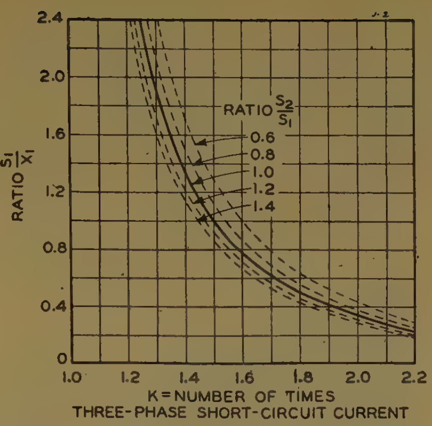

Figure 2. The currents in the neutral reactor for the indicated conditions may be determined from these curves

For

$X_1 = X_2$; S_0 = *infinite*

Then

$$X_R = \frac{X_1-X_0}{3} \text{ in per cent}$$

$$I_R = (k)\,\frac{e \text{ in per cent}}{X_1} \text{ per unit}$$

grounds. The ratio of X_0/X_1 on the terminals of the generator should be held to 4 or less to limit transient voltages. Special studies should be made if this ratio is greater than 4. Some discussion will be given later on transient voltages.

In applying neutral reactors to generators which supply distribution feeders at generator voltage, the voltage to ground on the two unfaulted phases should be checked. This is particularly important on cable systems. The higher the value of grounding reactance, the higher will be the voltage to ground on the two unfaulted phases.

The current I_R in the neutral reactor will always be larger than the current in the faulted phase when the generator is connected to a system with other machines because zero-sequence current circulates through the system in the two unfaulted phases. If the generator is an isolated unit, with no transformer path for zero-sequence currents to flow, the current through the reactor will be the same as the current through the faulted phase or generator winding.

It is sometimes necessary to determine the reactor characteristics for several different-size generators operating in parallel. This must be considered specifically and calculations must be made to cover all possible combinations and arrangements of generators. A neutral reactor must be selected to cover the worst condition. If the machines are similar in every respect, the problem is greatly simplified. If the machines are sufficiently similar, and it is desired to operate only one unit grounded at a time, one reactor between the neutral bus and ground may be used for all machines; the desired machine should be connected to the ground

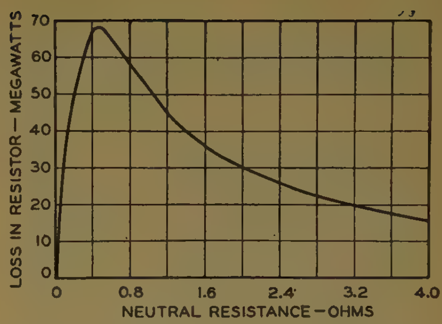

Figure 3. Power absorbed during single-phase-to-ground faults by different sizes of neutral-grounding resistors on a 31,250-kva 13.8-kv synchronous generator

bus through its neutral circuit breaker. When two or more generators connected to the same bus are grounded through low-impedance devices simultaneously, there is the possibility of excessive circulating currents between the generator neutrals. This point should be checked.

RESISTOR

For practical application the ohms required in a neutral resistor can be determined by fixing the maximum desired ground current and dividing the generator phase-to-neutral voltage by this current. The generator reactance can usually be omitted.

$R = e/I$ ohms in resistor

The current through a neutral resistor is usually limited for large generators to a minimum of about 100 amperes and to a maximum of about 1.5 times the normal rated generator current. To limit the neutral current to 100 amperes requires an 80-ohm resistor for a 13.8-kv generator; above 80 ohms the resistor length usually increases, the same cross-section area being used for mechanical strength which necessitates a larger frame and more material. The other limit of 1.5 times normal rated current is desirable to prevent excessive loss in the resistor during single-phase-to-ground faults. A value of 1.5 times normal current through a neutral resistor gives a kilowatt loss of 50 per cent of the kilovolt-ampere rating of the generator. If the current is allowed to be several times full load by using a resistor of fewer ohms, the loss in the resistor may be several times the normal full load of the generator. This is illustrated in Figure 3 for a 31,250-kva 13.8-kv generator for a single-phase-to-ground fault on its terminals. A resistor of 0.47 ohm gives a loss of 68,000 kw. A sudden increase in load such as this may cause damage to the generator shaft and couplings to the turbine and may be detrimental to system stability.

One application of neutral resistors is in those generators which are connected directly to delta windings of step-up power transformers. In such instances full displacement of the neutral during a fault is

not considered objectionable. Neutral resistors are also used on certain systems where power is sent out at generated voltage and where it is stepped down through transformers connected in delta on the generator-voltage side. In many such instances a resistor can be applied to limit current to almost a fixed value for a fault anywhere on the system. This is true because the effect of the resistance and reactance of any distribution feeder is small within the practical range of the neutral resistor. This situation may be altered if current-limiting reactors are used in the feeders.

SMALL POWER OR DISTRIBUTION TRANSFORMER WITH SECONDARY RESISTOR

A generator may be grounded through a small power or distribution transformer, the secondary of which is shunted by a resistor to provide safe and economical phase-to-ground fault protection to the generator circuit. The transformer in this device serves only as a means of making a low-ohm resistor in effect a high resistance in the neutral. The transformer does not necessarily have to be placed directly under the generator because a separate vault or compartment near the generator can be provided and a single-conductor insulated cable run from the neutral of the machine to the transformer. The transformer is usually in the order of 25 to 50 kva, with a ratio which may be as high as 120 to 1. The current for a single-phase-to-ground fault on the generator terminals is usually limited by this grounding scheme to values in the order of ten amperes or less.

This scheme, Figure 4, is particularly adaptable for generators connected to delta transformer windings. Relaying of the generator for ground faults is accomplished by either a current or a voltage device on the secondary of the neutral transformer. In some instances, since the current which flows for a ground fault is small, some operators have delayed the tripping of the generator for a predetermined time to let the operator remove the generator load. This will prevent the sudden loss of one generator from the system and the disturbance which follows the abrupt dropping of generation. One method of doing this is to provide an alarm and a timing relay set for a predetermined time which will trip the generator automatically in the event the operator has failed to do so. The possibility of further damage at the point of fault opens this procedure to argument, but in certain cases the gains outweigh the chances taken.

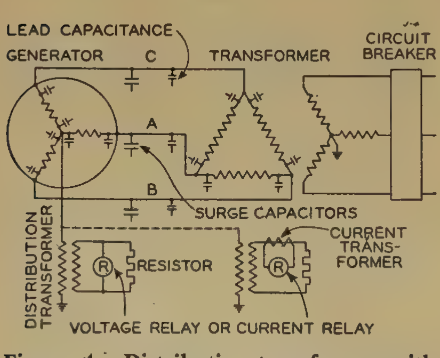

Figure 4. Distribution transformer with secondary-resistor grounding scheme

The size of the transformer and resistor is related to the distributed capacitive current to ground in the event of a ground fault. Therefore, the capacitance to ground must be known for the generator, generator terminal leads, the transformer low-voltage winding, and terminal surge capacitors. Several factors are involved in determining transformer and resistor sizes. The practical result is to make the transformer current equal to the capacitive fault current and the resistor kilowatt loss equal to the capacitive fault kilovolt-amperes. This proportioning will avoid the ferroresonance possibility of an unshunted neutral transformer, prevent high transient voltages in case of arcing faults or switching, and will swamp harmonics present in the potential indication making possible a low setting for the ground relay.

The above proportioning also prevents false tripping of the relay as a result of phase-to-ground faults on the high-voltage side of the main power-transformer bank. For this fault location there will be a zero-sequence-voltage capacitive coupling through the main power transformer to the generator neutral. False tripping is avoided because the resistance and particularly the reactance of the ground transformer and resistor are relatively low compared to the coupling capacitance between the high- and low-voltage windings of the main power-transformer bank. If the neutral of the high-voltage winding of the power-transformer bank is grounded solidly, this condition will not cause trouble; but if the transformer neutral is ungrounded or grounded through a high-impedance device, there is the possibility of false tripping for low settings of the ground relay.

The grounding transformer for any generator will seldom be required to exceed a rating of about 50 kva and is of standard distribution-type construction. The insulation class should be the same as that of the generator. For 13.8-kv generators the transformer should be a 13.8 kv to 440, 220, or 110 volts even though a maximum of about 8.0 kv is the dynamic voltage which will be applied on ground faults.

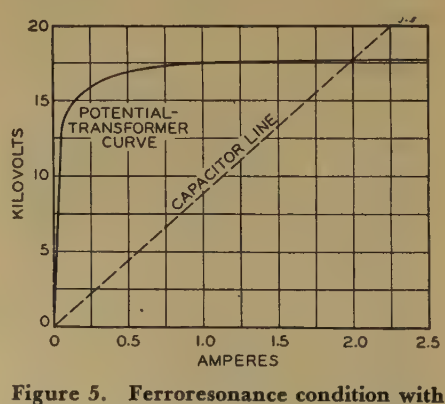

Figure 5. Ferroresonance condition with potential transformer in generator neutral

$jX_{PT}=j8{,}850$ *ohms* $c=0.3\ \mu f$

$-jX_C=-j8{,}850$ *ohms* $f=60$ *cycles*

As an example, assume a 62,500-kva air-cooled 1,800-rpm 13.8-kv generator connected to the delta winding of a power transformer through 200 feet of four 1,000,000-circular-mil 15-kv paper-insulated lead-covered cables per phase. The capacitance of the three phases of the generator is 1.05 microfarads; the capacitance of the cables is 0.49 microfarad; that of the power transformer is 0.04 microfarad; and that of the surge protective capacitors amounts to 1.50 microfarads. The total for all parts of the circuit is 3.08 microfarads. The total capacitive reactance will then be 860 ohms. With full line-to-ground voltage a total capacitive reactive power of 73.8 kilovars is obtained. A standard 50-kva 13.8-kv/230 volts distribution-type oil-filled transformer will be adequate for five minutes. The current through the primary winding of this transformer will be 9.27 amperes and the secondary current will be 556 amperes. Thus the resistor in the secondary must be designed to carry the current of 556 amperes for five minutes and have a resistance of 0.24 ohm to give a loss of 73.8 kw.

POTENTIAL TRANSFORMERS

A generator with a potential transformer in the neutral is grounded only through the capacitance to ground of the generator windings, bus work, transformers, cables, and surge capacitors. The potential transformer is only a device for measuring the voltage between the neutral and ground. To make certain that this is the case, the potential transformer must be liberally designed so that under no circumstances will its exciting current be appreciable compared with the circuit charging current to ground. If it is appreciable then a condition of ferroresonance may occur where the inductive reactance of the potential transformer as a result of saturation on overexcitation may approach the capacitive reactance and extremely high voltages may be present. Generally a

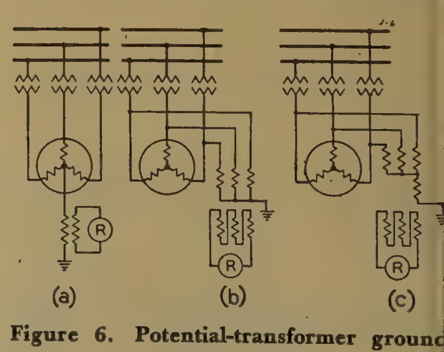

Figure 6. Potential-transformer ground detectors

potential transformer designed for line-to-line voltage placed in the neutral will be free from ferroresonance difficulties. However, if the potential transformers are to be applied on the terminals of an ungrounded generator, a voltage class higher than the line-to-line voltage ratings should be used. A potential transformer on the terminals of the generator will be liable to higher transient voltages than one in the neutral and, therefore, more apt to become involved in ferroresonance. Figure 5 shows how ferroresonance can take place; it occurs at 60 cycles where the exciting current for the potential transformer is equal to the shunt capacitive current. Potential transformers in the neutral or on the terminals will not prevent excessive transient overvoltages.

Three forms of ground-fault detection for generators may be had with potential transformers as shown in Figure 6. A single potential transformer, Figure 6a, may be used in the generator neutral so that a ground fault on the circuit comprising the low-voltage winding of the power transformer, connecting leads, or generator winding will produce a voltage on the relay for tripping or alarm purposes. Three potential transformers connected in star, Figure 6b, applied to the terminals of the generator will function in the same manner. This scheme has an advantage over one potential transformer because it can be set more sensitively. In addition, with three transformers, the machine will be tripped or an alarm will be given in case of an open circuit in the primary of a potential transformer. For a neutral potential transformer, if there is sufficient generator-circuit capacitance, the triangle of line voltage will tend to be stabilized with reference to ground and the residual harmonics will appear between neutral and ground. The relay must be set above any such harmonic voltage, which decreases its sensitivity and the protection of the generator windings near the neutral. Usually this will not be a serious handicap, although in extreme cases as much as 15 per cent of normal phase-to-neutral voltage might exist between neutral and ground. The scheme with three potential transformers avoids this situation.

In both of the foregoing uses of potential transformers the sensitivity of protection decreases as the ground fault approaches the neutral point. This is not often a serious handicap as most faults are on the generator terminals or near the line end of the generator winding. For complete protection within the generator windings a scheme which involves displacing the neutral continuously, Figure 6c, by means of an auxiliary winding on one potential transformer may be used. When a ground appears anywhere, even on the neutral lead, a voltage will appear across the relay.

As mentioned before, potential transformers properly applied serve only as

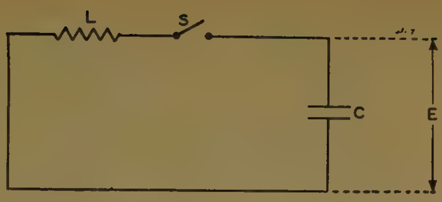

Figure 7. Capacitance–inductance circuit

Resonant frequency is $f=\dfrac{1}{2\pi\sqrt{LC}}$

voltage-measuring devices. Insofar as transient voltages caused by an arcing ground or switching of the generator circuit breaker are concerned, the generator is an ungrounded machine and therefore subject to the hazards of ungrounded operation. This situation may be improved in some cases by placing a resistor across the secondary winding of the potential transformer in parallel with the voltage relay.

Whenever potential transformers are used, there is some risk of false indication caused by ground faults on the high-voltage system as a result of the zero-sequence capacitive coupling between the high-voltage and low-voltage windings of the main power transformers.

INFINITE IMPEDANCE (NEUTRAL UNGROUNDED)

An ungrounded generator connected to a reactance-grounded system where X_0/X_1 is 4 or less is considered satisfactory from a transient-voltage standpoint. Where X_0/X_1 is greater than 4, it may be necessary to ground the generator to reduce materially the probability of excessive transient overvoltages. Where an ungrounded generator is connected to a resistance-grounded system, the resistance path is usually low enough in ohms to allow sufficient current to flow for relaying line-to-ground faults. Under these conditions it is usually safe to operate one or more generators ungrounded without fear of excessive transient voltages. In ungrounded generator operation the generator or generators are connected to an ungrounded system or to the delta winding of a step-up power transformer.

There are a number of objections to the operation of ungrounded generators (ratio X_0/X_1 infinite):

(*a*). It is not possible to relay for ground faults either in the generator or on feeders which may be supplied at generator voltage.

(*b*). It is possible for arcing ground faults outside the generator to develop transient voltages high enough to puncture generator insulation.

(*c*). Circuit-breaker operation may cause high transient voltages which may cause failure of generator insulation.

(*d*). Phase-to-phase faults are more probable than on a grounded generator. If feeders are supplied at generator voltage, two feeders may be tripped simultaneously by phase-to-ground faults on different phases.

(*e*). Feeders supplied at generator voltage will not trip for a broken wire which touches ground, thus constituting a public hazard.

TRANSIENT VOLTAGES ON GENERATORS

Transient overvoltages have caused the electrical failure of equipment and circuit insulation. Undoubtedly, there have been failures where these voltages were the cause but where the convicting evidence was destroyed. Generally lightning arresters are not recommended for protection against transient overvoltages; nevertheless, there are some situations where it is difficult to avoid depending on arresters for this protection. Evidence is available which shows that arresters have operated on transient overvoltages thus protecting equipment.

To explain the fundamental reasons for the production of transient voltages, refer to Figure 7. The capacitor C is charged by a direct voltage E after which the voltage is removed. When switch S is closed the capacitor will discharge through the inductance L and the circuit will oscillate at the resonant frequency determined by

$$f=\frac{1}{2\pi\sqrt{LC}}$$

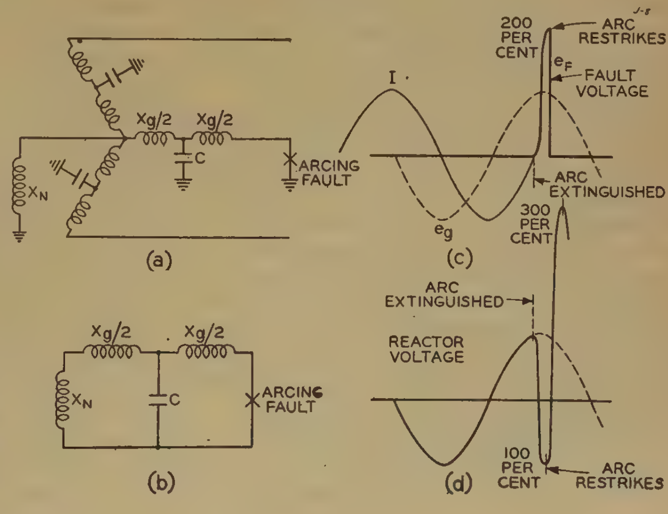

Figure 8. Arcing fault at the terminals of a three-phase generator grounded through a reactor

L is in henrys and C in farads. If the circuit has no loss, that is, no resistance, it will oscillate indefinitely. It is this oscillating, plus the normal circuit voltage, plus restriking; which enables high transient voltages to exist on a-c circuits.

Figure 8 shows a reactor-grounded generator and a phase-to-ground fault on one phase. Assume that the neutral reactor is large compared with the reactance of the circuit so that most of the voltage drop across the reactance in the circuit will be across the neutral reactor. Since the circuit consists mostly of reactance, the fault current will lag the voltage by about 90 degrees as shown in Figure 8c. Assume that at the instant the current is about zero the arc is extinguished, that is, the fault clears; then the voltage across the capacitance tries to assume the normal circuit voltage, but in making this attempt it overshoots to a point which is 200 per cent above ground. In other words, the circuit oscillates around normal voltage. The fault voltage indicated is also the voltage across the capacitor after the fault arc clears. If the insulation strength at the point of fault is such that the arc is re-established, the voltage across the fault drops from 200 per cent to zero and the capacitance voltage drops to a small value. The voltage across the reactor shown in Figure 8d goes from -100 per cent to $+300$ per cent. This takes place because of the reactance $X_g/2$ between the capacitance and the fault. If this reactance had been zero, the reactor voltage would go from -100 per cent to $+100$ per cent, and no more, at the instant the arc restrikes. The reactance $X_g/2$ between C and the fault is enough to allow an oscillation between the capacitance C and the two reactances in parallel. Most of the voltage drop will be across the neutral reactor and the voltage will oscillate from -100 per cent about normal voltage as reference and thereby reach a maximum for one restrike of 300 per cent. This voltage is across the neutral reactor; it can be seen that the instantaneous generated voltage on the two unfaulted phases must be added to the neutral voltage to get the maximum on the machine windings. The faulted phase also has a voltage to ground which is higher than the voltage across the neutral reactor. Inherently a neutral reactor adds to system reactance to give currents during fault conditions which lag the voltage by a large angle. This means that fault-current zero occurs when the instantaneous voltage is near maximum and, therefore, in a favorable position for oscillations involving series inductance and shunt capacitance of the system. A system grounded through a resistance, on the other hand, causes fault currents to be more nearly in phase with the voltage. If the current were exactly in phase with the voltage, current zero would occur at the same instant as voltage zero; the arc would go out and there would be no appreciable voltage to cause oscillations.

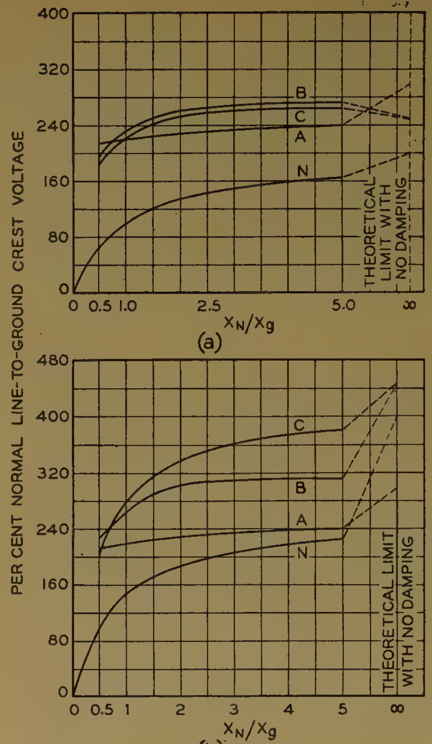

Figure 9. Effect of neutral reactance on transient voltages

(a). No restriking
(b). One restrike
A, B, and C represent line-to-ground voltages. N represents voltage across neutral reactor

With resistance grounding, fault currents actually lag the voltage by varying amounts, but the magnitude of voltage at the instant of current zero is usually small enough to prevent excessive transient voltages even if oscillations do occur. In addition, successive peak voltages during restriking are limited in magnitude due to the effect of losses in the neutral resistor.

Figure 9 shows line-to-neutral voltages which may be obtained on the various phases of a generator with reactor grounding. Figure 9a is for no restrikes and Figure 9b is for one restrike. These curves give voltages higher than the 300 per cent in the explanation above because the arc extinction voltage adds to the drops across the reactance and capacitance.

Figure 10 gives peak transient voltages for the distribution transformer scheme. The voltage is plotted against the ratio of the kilowatts loss in the resistor to the capacitive kilovolt-amperes of the circuit. This curve was made specifically for a 75,000-kva, 11-kv generator; however, it will also apply almost directly to all installations of this type. If the ratio of kilowatts loss to capacitive kilovolt-amperes is kept to one or greater, the peak voltage can be held down to about 2.6 times normal peak line-to-neutral voltage, which is less than 75 per cent of the generator test voltage when new.

Figure 10 can also be used to show the

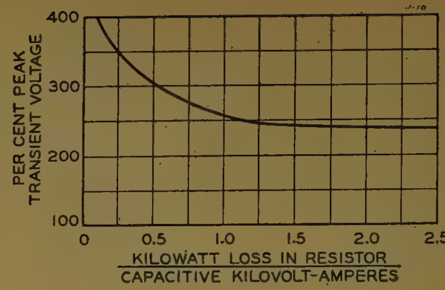

Figure 10. Maximum transient voltage during line-to-ground faults with distribution-transformer grounding scheme

magnitude of possible transient voltages on ungrounded or potential transformer grounded machines. In these cases the loss in kilowatts is very small so that the ratio of kilowatts loss to capacitive kilovolt-amperes is also very small, in the order of 0.2 or less. Thus, transient voltages of 4 to 5 times normal line-to-ground crest may be reached.

The discussion on transients has dealt with arcing phase-to-ground faults. The same phenomena can take place during switching operations where arcing takes place across the contacts when the switch is operated.

GROUNDING DEVICES FOR ONE OR TWO GENERATORS

Figure 11 shows a number of schemes for grounding a single generator. Each scheme is in use at present and each has a recommended application with the exception of the potential transformer. Figure 11a shows a low-reactance reactor where X_0/X_1 at the terminals of the generator is 4 or less; the reactor gives high phase-to-ground fault current for feeder relaying but minimum neutral displacement for circuit-insulation consideration. Figure 11b shows a resistor which limits the current to a maximum of about 1.5 times rated generator current and gives sufficient ground-fault current for feeder relaying but allows about full displacement of the neutral for single-phase-to-ground faults. The schemes of Figures 11c, d, e, and f are all workable layouts for unit system operation, but the two schemes using the distribution transformer are preferable because they limit single-phase-to-ground-fault currents to small values and at the same time protect the generator from excessive transient voltages. The potential transformer schemes of Figures 11g and h are not recommended because of the possibility of excessive transient voltages and ferroresonance. In Figure 11i the generator must be tripped immediately upon the occurrence of a phase-to-ground fault within the generator-differential-relay zone by differential relays. To give protection to the station service bank and the distribution feeder, these must be included in the generator-differential-relay zone or else must be provided with circuit breakers and sepa-

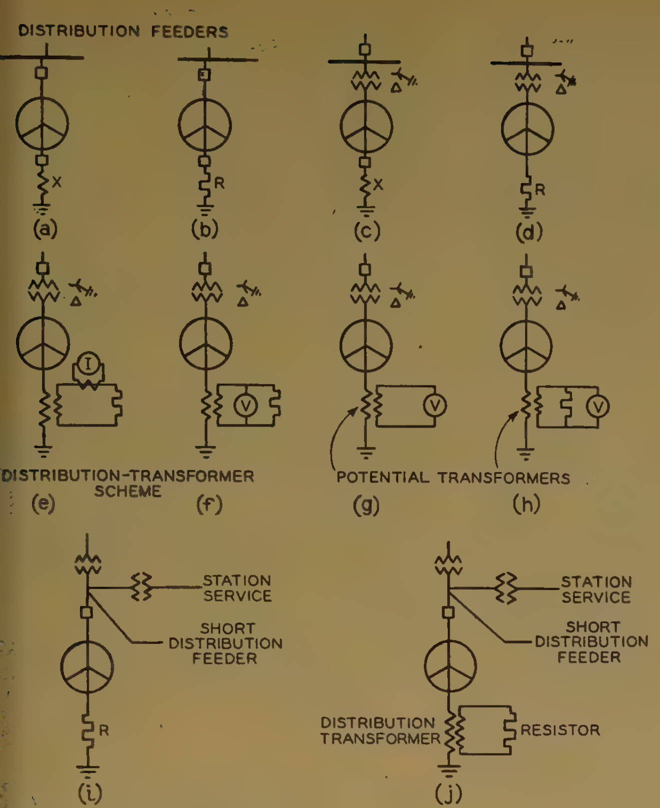

Figure 11. Grounding schemes for one generator

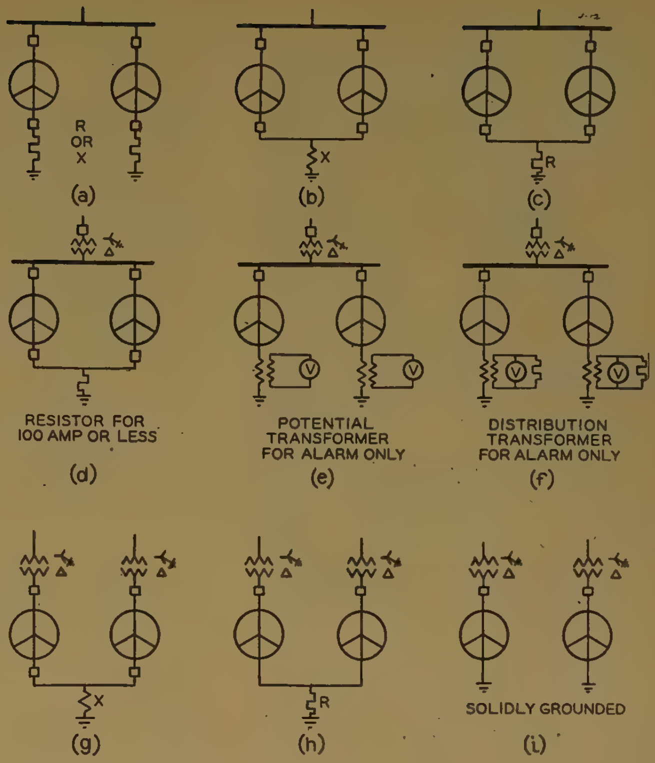

Figure 12. Grounding schemes for two generators

ate relaying. For this type of layout iere are a number of questions regarding rotection of all parts of the circuit. It is elieved that the distribution transformer iown in Figure 11j provides satisfactory rotection for ground faults. For phase-›-phase or three-phase faults other re-ıying must be provided for all parts of ıe circuit at generator voltage.

Schemes for grounding two generators re shown in Figure 12. The reasoning ›r a two-generator station is also applied › stations having a greater number of nits. Figures 12a, b, and c are subject to ıe same limitations as one generator rounded through reactors or resistors. 'or a station with two or more generators : may be necessary to ground only one enerator at a time to prevent excessive irculating current between the neutrals f the machines. When only one of several enerators is grounded through a reactor, ıe ratio of X_0/X_1 should still be main-ained at 4 or less. The ratio X_0/X_1 is etermined from all sources at the ter-ıinals of a given generator and not solely om the constants of the generator being onsidered. Figure 12d is not a recom-ıended grounding scheme because of the elaying problem for single-phase-to-round faults. It can be used, however, y applying zero-sequence differential re-ıying to select a faulted generator. The ult current for this type of grounding ould probably be too small for operation f the normal differential relays. Figures 2e and 12f show the use of grounding evices for alarm or indicating purposes ; there is no selectivity between the two enerators. A fault on one generator causes the operation of the ground devices on both generators. To get selectivity a grounding device must be used which will allow sufficient fault current to flow to operate the differential relays on the generator at fault. The schemes shown in Figures 12g and 12h are workable and must trip for ground faults on currents high enough to operate the differential relays. The solidly grounded scheme of Figure 12i is not recommended because of the high currents which will flow for single-phase-to-ground faults. In fact, for the last three cases it is recommended that a distribution transformer grounding scheme be used for each generator as in the case of a single machine.

GENERATOR PROTECTIVE EQUIPMENT

A discussion of generator grounding would be incomplete without comments on the effects of various grounding devices on generator protective equipment.

Differential Relays. Differential relays are used on most generators having ratings above 1,000 kva regardless of the method of grounding. They will disconnect the generator from the system for any type of fault within the protected zone provided sufficient current flows to operate the relays. The protected zone consists of the generator windings, generator leads, surge capacitors, if any, and the generator circuit breaker. A generator differential relay is insurance against excessive damage to the generator and as such initiates a number of operations for completely removing the unit from service. The following operations are usually performed:

(*a*). Trips main generator circuit breaker.

(*b*). Shuts off the steam supply to the turbine or the water supply to the waterwheel.

(*c*). Causes fire-extinguishing equipment to operate in the generator housing.

(*d*). Actuates the mechanism for reducing the main field flux.

(*e*). Trips neutral circuit breaker.

In those generators where high-impedance neutral devices are used, the differential relays will not operate for ground faults. A ground relay must be inserted in the neutral to perform the same function as the differential relays with perhaps certain modifications. For example, with a high-ohm resistor the neutral breaker will probably be omitted and, therefore, the neutral connection cannot be opened.

Neutral Circuit Breaker. The purpose of an automatic single-pole neutral breaker as shown in Figure 13 is to disconnect the neutral of the generator from ground on

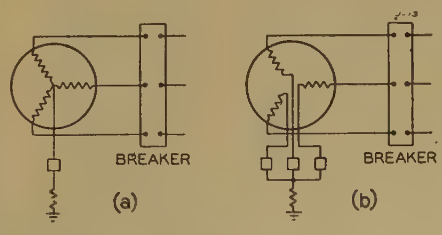

Figure 13. Generator-neutral circuit breakers
(*a*). *Single pole*
(*b*). *Three pole*

single-phase-to-ground faults. Since the probability is that practically all faults within the generator-differential-relay zone will be single-phase-to-ground, the use of an automatic neutral breaker is important. By having the differential relay open this breaker the path for heavy ground current is opened and consequently the damage to iron is minimized. A small current will continue to flow in the ground fault through the capacitance to ground of the generator and leads after the neutral breaker is open which may cause transient voltages injurious to generator insulation; but it is usually better to take a chance on this than run the risk of burning the iron excessively. This small current, however, should not cause material damage beyond what had been caused before the neutral breaker opened. Of course, the field-reducing mechanism has also been placed in force, and in a matter of several seconds the generated voltage will be down practically to zero.

The neutral breaker should be of such kilovolt-ampere rating that it will interrupt the maximum rms current flowing through the neutral during a single-phase-to-ground fault on the terminals of the generator. The maximum rms current which will flow is more than the current through the faulted phase and can be determined from the formulas given in Figure 1. The voltage rating of the breaker should be the same as line-to-line voltage of the generator.

In an attempt to get better protection for generators grounded through low-impedance devices, the use of three-pole neutral breakers has been suggested as shown in Figure 13b. The advantages of using this breaker instead of a single-pole breaker are questionable and there are also certain major objections. A three-pole breaker costs more, and any operating difficulties may be very hazardous to the generator; if the breaker should be tripped accidentally, it would cause a generator outage; if one pole should open, it would cause single-phase operation of the generator which could be very serious and accentuate the problem of maintenance. Since more than 75 per cent of the expected faults are single-phase-to-ground, a single-pole breaker will interrupt the fault current. Transient overvoltages may be caused with both types of breakers although there may be a slight advantage on this point with a three-pole breaker. When the generator is tripped for single-phase-to-ground faults or any other type of fault, the field circuit is also tripped; and in several seconds the generator-field flux will decrease to a negligible value, thereby reducing fault voltage and current practically to zero. When a single-pole neutral breaker is used, some chance is taken because, after this breaker has opened and before the field flux has decreased to a low value, transient overvoltages may be produced on the ungrounded generator which could damage insulation elsewhere in the generator windings. It is believed that this chance should be taken in view of the other operating advantages of the single-pole breaker.

Sometimes nonautomatic neutral breakers are used, but these cannot be opened during a fault and therefore are little better than a disconnect switch. To be fully effective the neutral breaker must be capable of interrupting the neutral current automatically during single-phase-to-ground faults.

FIELD-REDUCING MEASURES

Field reducing of some form is desirable to minimize possible damage to windings and iron in a generator if a fault should occur. Even after the main circuit breaker has been tripped by relay operation, the current in the fault will continue to flow as long as a complete circuit exists and there is field flux in the generator. If a single-phase-to-ground fault is assumed on one phase of a reactor-grounded generator, without an automatic neutral breaker, a fault current will flow until the field flux has been reduced to a low value. This is true even though the power to the turbine may have been shut off completely, because the inertia of the machine is sufficient to keep the speed about normal for some time. Figure 14 shows current-decay curves for a 30,000-kva synchronous condenser; curve *a* is for condenser field opened on a discharge resistor and curve *b* is for opening the exciter field. For faults involving more than one phase, there will be a path for fault current either with or without the neutral grounded. Line-to-line or three-phase faults are very unlikely and very rare, but if one should occur, field reducing will limit burning of insulation, copper, and iron.

The simplest and most direct form of field reducing requires a main-field circuit breaker. When the differential relay or any other relay operates to trip the generator, the same relay should also actuate the tripping mechanism of the main-field breaker. This breaker is arranged so that a resistor is short circuited across the main field before its contacts actually part. The resistor will cause the field current to decrease in a shorter time due to the fundamental relation of $i=e^{-Rt/L}$, where the current i is flowing t seconds after the source of electromotive force is short-circuited on a circuit carrying I amperes and having resistance of R and inductance of L. The larger the value of R, the faster the current will decay; however, the usual practical value of resistance is such as to keep the maximum voltage drop across the main field to about 600 volts. The maximum R equals 600 divided by the maximum field current. This method of field reducing, however, cannot be used for a large number of generators because main-field breakers are not provided.

On generators with excitation systems using pilot exciters, without main-fiel breakers, operation of the differential re lays will short-circuit the field circuit the main exciter through a discharg resistor and allow the main-field curren to discharge through the armature of th main exciter. This method takes longe than the one mentioned in the foregoin for a main-field breaker because the tim constant of the circuit through which th current discharges is greater, since th inductance is essentially the same and th resistance is less.

Where the main exciter has a differen tial-field winding, there is also the possi bility of opening the field of the excite and leaving the differential field energize from the pilot. The differential field wi be effective in reducing the time constan of the main-field circuit and thereby hel to reduce the main-field current mo quickly.

Ground Relays. On generators wher the ground-fault currents are great enoug to operate the differential relays, thes

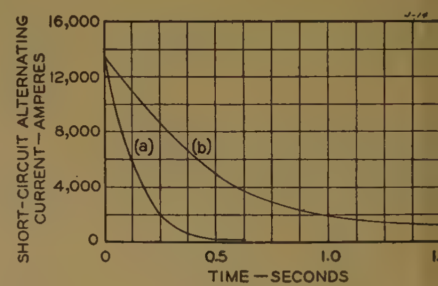

Figure 14. Calculated decay of fau current in a solidly grounded 30,000-kv 10-kv synchronous condenser

(*a*). *Main field short-circuited*
(*b*). *Exciter field short-circuited*

relays will clear the generator for all type of faults and ground relays are therefor unnecessary. In those instances wher the generator or system is grounded i such a way as to limit the single-phase-to ground fault current to small values, neutral ground relay should be applied.

For most generators with ground relay the generator trips immediately upon th occurrence of a fault. There are, howeve exceptions where single-phase-to-groun faults are allowed to persist until the un can be removed. In these cases an alarm is given, and in some applications a time is set to trip the machine automaticall after a predetermined time.

For a single generator connected to th delta winding of a transformer where resistor or a small power transformer wit a secondary resistor is used, a current voltage relay may be used to trip th generator for a single-phase-to-groun fault. A current transformer with a cu rent relay is usually placed at the grounde end of a neutral resistor. A current voltage device may be used in the secon

ary; with the small power transformer, if it is a current device, a current transformer will be needed.

Where two or more generators with neutral resistors are bussed, the machine which has a single-phase-to-ground fault may be selected and tripped by means of zero-sequence current relays connected differentially. One zero-sequence measurement is required in the neutral of each generator and one on its terminal at the common bus.

Capacitors for Surge Protection. For 11.5-kv and 13.8-kv grounded generators, one standard one-fourth-microfarad capacitor unit is recommended on the generator terminals, whereas for generators in the ungrounded classification two standard one-fourth-microfarad units are recommended. In general, for surge capacitors, any generator grounded through a resistor of 50 ohms or less or solidly grounded is considered grounded. Generators having a reactor, a potential transformer, a small power transformer, or no ground should be considered ungrounded.

Lightning Arresters. For all generators about 1,000 kva and larger, special station-type lightning arresters should be used at the generator terminals. For generators less than 1,000 kva, special station-type arresters are usually too costly but special line-type arresters may be applied economically. In all cases, standard line-type arresters or protector tubes should be placed on every overhead line entering the station at generator voltage. Ungrounded generators or generators grounded through resistance devices require a higher-voltage-rating arrester than generators grounded solidly or through low-reactance devices. Both line- and station-type arresters must be applied on the basis that the rms voltage from line to ground across the arrester under any normal or fault condition does not exceed the arrester phase leg rating.

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Wide-Band Program-Transmission Circuits

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Broadcasting stations employing frequency modulation require circuits from studios to transmitters and between network stations that are capable of transmitting wide frequency bands in order to realize the high-fidelity characteristics of this system. Postwar plans of telephone companies include consideration of such requirements; considerable progress already has been made in building the necessary plant.

GROWTH of frequency-modulation broadcasting was interrupted by the war. The present interest in frequency modulation indicates a resumption of activity and an expansion of this type of broadcasting soon after the war ends. A recent review showed that applications have been filed with the Federal Communications Commission for more than 250 frequency-modulation broadcasting stations scattered throughout the United States. Among other things, these stations will need communication channels between main studios, from studios to transmitters, and from remote pickup points. The telephone companies have provided these for standard broadcast stations in the past and they are providing such facilities today for frequency-modulation stations now in operation.[1]

With extensive development of frequency-modulation broadcasting, it is possible that new and different types of facilities may be found desirable. However, the extent of such communications facilities and the desired characteristics can only be developed with time. Presumably the broadcasters will formulate their needs as soon as the requirements are more clearly visualized. Depending on the way these requirements develop and are affected by varying local situations, they may cover quite a range of conditions and types as is the case in standard broadcasting. Fortunately, the various types of facilities which the telephone companies furnish today, or can furnish in the future, likewise cover quite a range—a range which appears adequate to meet any likely requirements for frequency-modulation broadcasting. The selection and arrangement of facilities will be done in the future as frequency-modulation broadcasting grows. However, the postwar plans now are being evolved and it is desirable, therefore, to review the available facilities and to outline some of the factors which may be worthy of consideration in formulating such postwar plans.

STUDIO–TRANSMITTER CIRCUITS

Since the beginning of radio broadcasting, the telephone companies have provided studio–transmitter circuits, transmitting up to 5,000, 10,000, and even to 15,000 cycles. Introduction of frequency modulation in itself does not impose any severe transmission problems for circuits of this type.[2]

The FCC Standards of Good Engineering specify that studio–transmitter circuits for frequency-modulation broadcasting stations should transmit satisfactorily a band from 50 to 15,000 cycles. There are about 45 commercial frequency-modulation broadcasting stations in operation today. All but six of them are using wire lines between studios and transmitters and these circuits are giving satisfactory service.

To take care of future requirements for circuits of this type is not expected to be very difficult. Generally the transmitters are not far from the studios and suitable circuits can be provided on wire lines over existing telephone routes. In a few cases, where the transmitter location is at a

Essential substance of a paper presented at a joint meeting of the communication group of the AIEE New York Section and the New York section of the Institute of Radio Engineers, October 4, 1944.

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Figure 1. Proximity of projected frequency-modulation broadcasting stations to present program-transmission routes

rather inaccessible point in rugged country, some special construction may be required to establish the channel. For some of these unusual cases, the use of radio may well be the best way to provide the circuits. More will be said later about the possible use of radio for communication purposes under such conditions.

LOCAL PICKUP CIRCUITS

The local circuits for picking up programs originating outside the studio also are being provided as required. For these circuits regular telephone plant is adapted for frequencies up to 15,000 cycles.

INTERCITY NETWORK CIRCUITS

Present-day radio service would be well nigh impossible if each broadcasting station originated in its own studios all the programs it transmits. There would not be enough Toscaninis or Charlie McCarthys to go around. An intercity network provides a means of making readily available to any broadcasting station on the network the best talent in any city reached by the network. This pooling of programs gives the best over-all coverage for the public and at the same time makes the average cost of such high-grade programs less to individual stations.

OBJECTIVES FOR NETWORKS

Broadly speaking, the objectives for network facilities to interconnect frequency-modulation broadcasting stations are much the same as for facilities to interconnect present-day stations. The more important f these would seem to be:

1. Transmission characteristics which will assure naturalness. This involves a satisfactory frequency band, adequate volume range, and freedom from appreciable distortion and noise.

2. Ready availability. There are distinct advantages in having the facilities engineered and installed in advance of need so that they may be put into actual use on reasonably short notice.

3. Flexibility. It is desirable to be able quickly to change the layout in order to broadcast special events or, perhaps in the middle of a program, to change the point of origin from the Atlantic Coast to the Pacific Coast.

4. Reliability. Adequate stand-by facilities are essential so that in case of failure of any link in the network, service can be restored with little interruption to the broadcast. Also, in case of storms, floods, fires, or other disturbances which might affect a particular route, it is desirable to have facilities available on another route to protect the service.

5. Co-ordination. For satisfactory results it is necessary that the nation-wide layout be built up in accordance with an over-all plan and that each link be designed so that it will fit into the layout with little change. Several typical examples will illustrate this:

(*a*). Providing satisfactory transmission on extensive networks requires close and continuous co-ordination of design, maintenance, and operation. Facilities which provide acceptable transmission between New York and Pittsburgh, for example, might prove wholly unsatisfactory for coast-to-coast network operation unless they were designed with that in mind.

(*b*). Tolerable over-all distortion may be apportioned in some approximate manner to individual sections for use as a guide in laying out these sections. However the real problem arises when these separate links are switched together to set up the extensive network and this requires over-all tests and adjustments.

(*c*). The equipment and methods used to compensate for cumulative distortion depend upon the characteristics of the individual circuit links connected together at a particular time. The individual links switched together in this manner vary from hour to hour. It will be evident that the problem of co-ordination to assure suitable over-all transmission becomes much more difficult if the individual links are designed and maintained independently of each other.

TYPES OF CIRCUITS

The transmitted frequency band for intercity program circuits varies depending upon the grade of service the broadcaster wants. The following classifications cover most of the circuits used at present:

1. From about 300 cycles to approximately 2,500 cycles, suitable for transmission of speech only.

2. From about 200 cycles to about 3,500 cycles, suitable for transmission of medium quality program material over limited distances.

3. From about 100 cycles to about 5,000 cycles.

4. From about 50 cycles to about 8,000 cycles.

Circuits used for program transmission require individual design consideration. In many cables now in plant, the intercity program circuits are operated on carefully segregated pairs that are specially loaded

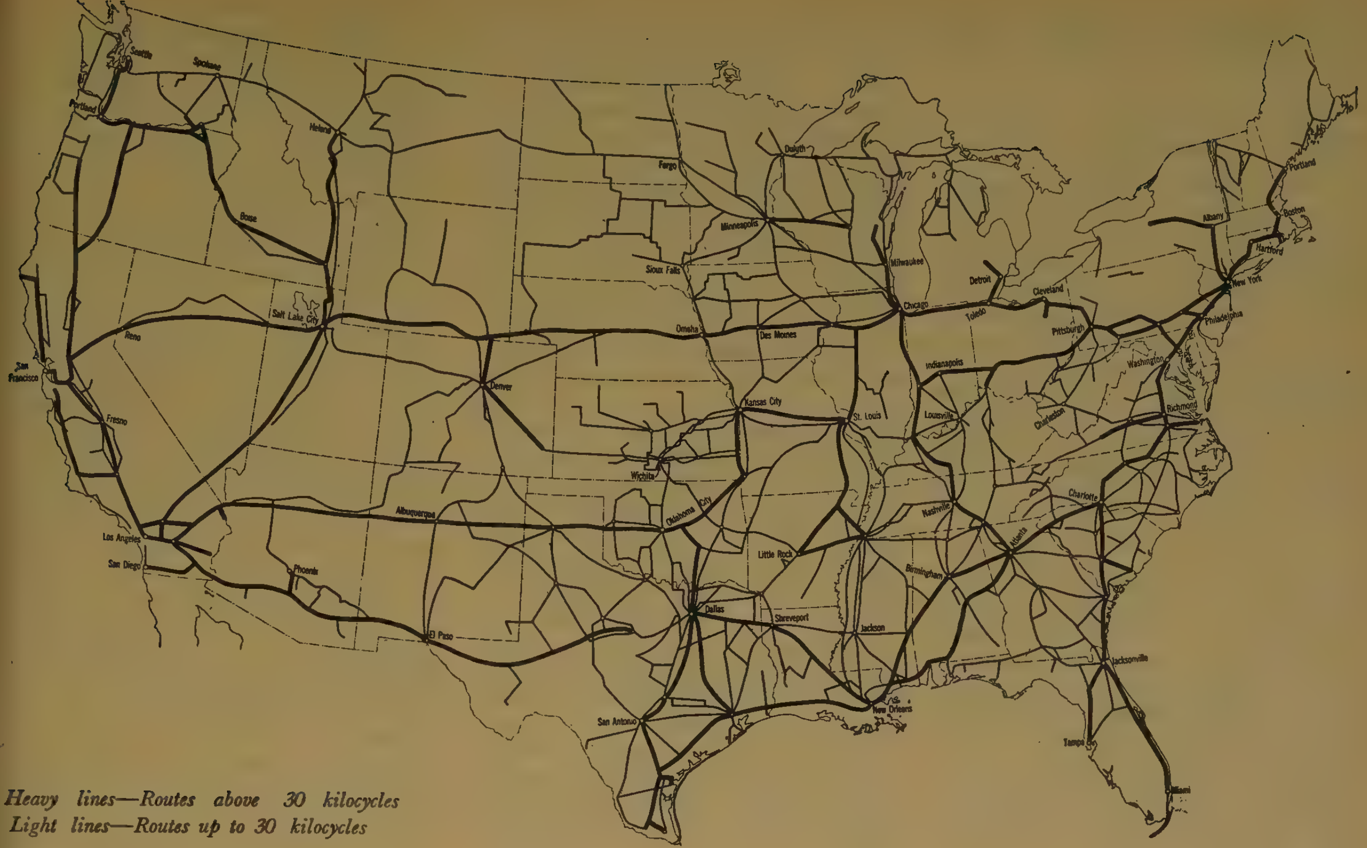

Figure 2. Intercity routes transmitting frequencies to 30 kilocycles or higher

and equipped with special amplifiers. Though much of this plant was installed more than ten years ago, it was so arranged that the facilities can readily be equalized to 8,000 cycles for circuits thousands of miles long and somewhat beyond 8,000 cycles for shorter circuits. This was done in anticipation of the possible need for higher-quality circuits by the broadcasting industry.

In recent years there has been a trend toward broad-band carrier systems in the telephone plant. With the cable carrier system, a block of frequencies extending up to 60,000 cycles is subdivided to obtain 12 telephone circuits.[3] The same frequencies are employed in the two directions, transmission in opposite directions being in separate cables. The cables may be either aerial or underground. On most of the newer cable routes, such as between Omaha and Sacramento, the two cables required are buried directly into the ground with a plow train which installs both cables and closes the trench all in one operation. On the older routes existing cables have been adapted for carrier transmission. Broad-band cable carrier systems are now in operation on more than 8,000 miles of route including Portland to Atlanta on the east coast; the transcontinental cables from New York through Chicago and Denver to San Francisco and Los Angeles; and important north–south routes from Chicago to San Antonio and from Chicago to Atlanta. It is now possible to talk entirely over cable carrier facilities from Portland, Me., to Los Angeles and very soon to San Diego.

A somewhat different broad-band system is used on open-wire routes.[4] It is similar to cable carrier in that a wide band of frequencies provides 12 circuits; it differs from cable carrier in that both directions of transmission are on the same pair of wires, which makes it necessary to use frequencies extending up to nearly 150,000 cycles.

The latest and broadest-band system to date is the coaxial system. With this the 12-channel group is used as a building block.[5] Five of these are first put together to form a supergroup of 60 circuits; next the wide bands of frequencies for eight such supergroups (480 circuits) are modulated so as to place the frequencies in different ranges and they are then located side by side in a frequency band several million cycles wide. This is transmitted over the cable, is amplified and equalized at intervals of about five miles, and is then subdivided again at the far end into 480 individual circuits.

What has all this to do with intercity program circuits? The point is that facilities of this kind may be used for program circuits to interconnect broadcasting stations. All these broad-band carrier systems employ in common the principle that a wide band of frequencies is subdivided to obtain 12 telephone circuits. For use with such carrier systems, special carrier program terminal equipment arrangements have been developed which enable a program circuit to be obtained by using the frequency space normally occupied by one or more message telephone circuits. Changes are not required in the line conductors and associated equipment. The number of telephone circuits displaced depends upon the frequency-band width desired for the program circuit. In the future, a program circuit may employ as much of this broad frequency band as the broadcasters believe is warranted.

The carrier program terminals as now designed are capable of providing circuits with band widths of 5, 8, or 15 kilocycles. Up to the present the equipment has been used only with the cable carrier system but it can be adapted to use with other broad-band systems.

Two varieties of carrier program terminal equipment have been developed:

1. A single-side-band system which is arranged so that several channels of the regular 12-channel group may be used for a program circuit, the remaining channels continuing to be used for message toll circuits.

2. A double-side-band system which employs less costly terminal equipment but uses the frequency space normally occupied by 12 message circuits.

Both arrangements should be useful after the war. The single-side-band system is likely to be preferable for the longer circuits because it permits more efficient use of line frequency space. The double-side-band arrangement would have advantages where the cheaper terminal

equipment and other conditions would warrant using for the program channel the entire frequency space available for 12 message circuits.

EXTENT OF PRESENT NETWORKS

There are four full-time nation-wide networks, plus a number of smaller regional networks. Altogether, the intercity wire lines serve on a full-time or occasional basis about 830 stations in some 550 cities. They employ about 90,000 miles of circuit for the regular full-time broadcasting period. In addition, about 45,000 miles of circuit are provided on these and paralleling routes to handle part-time services and to make possible quick restoration of the program in the event of an occasional failure of the regular layout.

SPECIAL OPERATION

Constant attention of many people is required for co-ordination and special operation of this nation-wide layout. During the short interval for station identification, switches may be required which result in a complete change in layout in a matter of seconds. For example, in a number of instances, a program originating in New York is broadcast by a group of eastern stations during the early evening. Because of the time difference it would still be afternoon in the Pacific Coast area. The program therefore is not broadcast by the far-western stations but is repeated for them from New York several hours later. For this second transmission all the stations in the east, which had broadcast the same program earlier, are disconnected from the network. Frequently these stations are connected to some other network section to permit broadcasting another program. In addition, switches are often made almost instantaneously during a program to change the point of origin—perhaps to employ talent in all parts of the nation in launching a war-loan campaign. Full-time monitoring of the program is done at certain key points on the networks, supplemented by part-time monitoring at other points.

The people engaged in co-ordination of the intercity layout are located in all parts of the nation and the nature of their work requires that they use uniform methods and have instantaneous communication between many points. Many thousands of miles of telephone and telegraph circuits are used exclusively in operation and maintenance of the program networks.

It will be evident from this brief description that provision of a smoothly working network of facilities to interconnect broadcasting stations involves more than the establishment of circuits between various cities. The arrangements for providing and operating such networks have been developed by the telephone companies over a period of years and these are available for use in extending the service to other areas as frequency-modulation needs may require.

NETWORKS FOR AMPLITUDE MODULATION AND FREQUENCY MODULATION

Figure 1 shows the location of frequency-modulation stations now broadcasting or for which applications have been filed. Practically all these are in or near cities on existing intercity program routes. Some of the present routes which might be used to interconnect the frequency-modulation stations are shown in the figure. Over these and other routes, not shown, the telephone companies are prepared to furnish the types of circuits previously described and newer types of services as required.

Some of the present frequency-modulation stations are now being supplied with distant programs over existing networks used with amplitude-modulation stations. It is entirely practicable to continue this arrangement or to provide separate networks for frequency-modulation stations if the broadcasting industry desires them.

A very large proportion of the present-day program-transmission networks is made up of circuits having a band width of about 100 to 5,000 cycles. As a step toward the use of higher-grade network facilities, circuits were made available several years ago with a band width of about 50 to approximately 8,000 cycles. Thus far there has been only a limited demand for these facilities. It may be that more use will be found for these or still wider band circuits as frequency-modulation broadcasting grows.

Looking toward such a possibility, the Bell System has carried on a program of research to develop better techniques and to improve quality so as to keep pace with the needs of the broadcasting industry. Periodically special demonstrations have been given of the results of such work.

A preview of some possible program network facilities of the future was given 11 years ago by the Bell Telephone Laboratories in a demonstration of auditory perspective between Philadelphia and Washington.[6] As the name auditory perspective implies, this preserves the spatial relationship of the original sounds so that an audience listening to the reproduced program experiences the same sense of depth as would an audience listening to the program at its origin.

For this demonstration, the Philadelphia Orchestra played in the Academy of Music in Philadelphia and the program was transmitted over the telephone cable to Washington and reproduced there before an audience in Constitution Hall. Three separate channels, each equalized to 15,000 cycles, were employed in this demonstration of higher-fidelity three-dimensional transmission and reproduction.

Another demonstration of the practicability of providing wide-band program circuits, this time over long distances, was given before a meeting of the AIEE at Philadelphia in 1941.[1] In this instance a 15,000-cycle circuit 1,200 miles long was employed. The circuit was operated in the regular telephone cables, using the same type conductor and amplifying arrangements as have been installed on thousands of miles of route for carrier-telephone operation. The terminal arrangements were those discussed earlier which were developed specifically for program transmission. They are of a type that can be made available in the postwar period as the needs of the broadcasting industry develop.

In furnishing their regular message toll service, the telephone companies have had many years of experience in transmitting frequencies higher than 15 kilocycles. The same basic principles apply whether these frequencies are used for program transmission or for some other communication service. The great amount of research that has gone into the development of carrier systems, plus the experience of adapting the results of such research to practical day-to-day problems, should be helpful in meeting the future needs for intercity program circuits. Figure 2 shows the nation-wide network of telephone routes now transmitting frequencies above 15 kilocycles. The lighter lines indicate routes employing frequencies up to about 30 kilocycles and the heavier lines represent routes using frequencies well above 30 kilocycles. Some are open-wire routes and some are cable routes. Together they form a network that fairly well blankets the populated regions of the United States.

LOOKING TO THE FUTURE

In the near future many routes will transmit frequency bands millions of cycles wide with high fidelity. The band width allotted to a particular circuit is a matter of design and depends on the intended use of the circuit. With the coaxial cables now being installed, the same cable may carry circuits hundreds of cycles wide for telegraph, several thousand cycles wide for message telephone, circuits still wider for program networks, and, finally, circuits millions of cycles wide for television. The Bell System tentative program for extension of coaxial cables during the next five or six years involves some 6,000 to 7,000 miles of new cables extending across the nation. This program is already well under way; coaxial cables have been installed from New York to Washington, Stevens Point, Wis., to Minneapolis, and Atlanta to Macon, Ga. Cable is now available to extend this to Jacksonville. The Terre Haute–St. Louis cable is being installed and the securing of approvals from various governmental departments is now in process for the Washington–Charlotte, Atlanta–Meridian, and Dallas–Shreveport cables, the first three links in the proposed extension of coaxial cable from New York to the Pacific Coast.

RADIO-RELAY TRIAL

In addition to the several types of wire systems described, development work is

in progress to make use of radio for this service. Experience with wire-line systems has indicated that program circuits can best be provided on the same open-wire lines and in the same cables with message telephone circuits and other communication channels. The Bell System has obtained approval to make an experimental installation of a radio-relay system between New York and Boston to determine if the radio system could handle a very wide band of frequencies which might be subdivided for various services such as message telephone, program circuits, and television circuits in much the same manner as is done with coaxial cable.

If this trial proves successful, the telephone companies in the future would expect to use radio links in program circuits where that method of transmission seems preferable to wire-line methods.

CONCLUSION

The question of how much band width to assign to a program transmission circuit depends on the requirements of the broadcasting industry. Whether the proper design objective for intercity circuits to connect frequency-modulation stations together is precisely 15,000 cycles, or higher, or lower, is uncertain at the moment. As stated earlier, the present extensive program networks are made up largely of facilities equalized to 5,000 cycles. However, if the broadcasters decide that they want circuits wider than 5,000 cycles, the telephone companies will be able to supply them, whether the demand be for 8,000 cycles, 10,000 cycles, 15,000 cycles, or even higher.

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Applications of Thevenin's Theorem

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FELLOW AIEE

In the solution of electric-circuit problems, little advantage has been taken except in communication work of the help that may be obtained by the application of Thevenin's theorem. Statements and proof of the theorem and examples of its use are given in this article.

TEXTBOOKS in communication engineering indicate that engineers in this field are aware of the fact that Thevenin's theorem offers a very convenient tool in the solution of electric-circuit problems. Electrical engineers in other fields, however, do not seem to have made a very thorough acquaintance with this theorem, which in many instances can be of considerable help in the solution of their problems. It is the purpose of this article to show by means of some examples from various fields how the theorem can be put to practical use.

Thevenin's theorem can be stated in several ways, of which the following is the most common. The current in any single branch of a network consisting of any number of impedances and voltage sources can be found in the following manner: open the branch under consideration and determine the open-circuit voltage appearing across the break; then consider all voltage sources as short-circuited or—if they have internal impedance—replaced by an impedance equal to the internal impedance of them and calculate the impedance of the network under this condition when looking into the two terminals of the break. The current that will flow in the branch under consideration after closing the break will be the open-circuit voltage divided by this impedance.

Sometimes the theorem is stated in the following manner: so far as any particular branch of a network of impedance elements and voltage sources is concerned, the network can be replaced by a single voltage source equal to the open-circuit voltage that would appear if the particular branch in question were removed from the network and in series with this voltage source an impedance that would be measured across the two terminals of the branch in question (but with this branch removed) and all voltage sources in the network either short-circuited or replaced by impedances equal to their internal impedance.

The proof of Thevenin's theorem rests entirely on Helmholtz's theorem of superposition; as a matter of fact, Helmholtz may have discovered Thevenin's theorem some 30 years before the latter. The principle of superposition states that in a network consisting of a number of linear impedances and a number of voltage sources, the total current distribution can be found by first determining successively the current distributions due to each voltage source acting alone in the network with all other voltage sources replaced by impedances equal to their internal impedance (that is, short-circuited, if the internal impedance is zero), and then superimposing all these current distributions on each other. The correctness of this method is self-evident because each current distribution so found will satisfy Kirchhoff's laws and consequently the superposition of all of them will also satisfy these laws. The proof of Thevenin's theorem on the basis of the superposition principle is given in the appendix.

EXAMPLE 1

Four 24-volt d-c relays with a current consumption of 0.1 ampere each are to be operated from a voltage divider connected to a 230-volt line. It has been ascertained experimentally that an application of 30 volts to the coils of the relays will not lead to undue heating. Figure 1A shows the actual setup. Obviously the voltage divider should be designed so that with all relays energized, the voltage across them will not be below 24 volts, while with one relay only energized, it should not rise above 30 volts. The four relays can be considered as a variable load, and Thevenin's theorem states that as far as this load is concerned, the actual network of resistances could be replaced by a single voltage source equal to the open-circuit voltage E' with all load removed and a resistance in series with this voltage equal

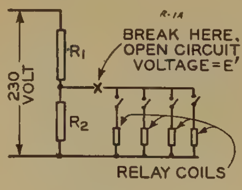

Figure 1A

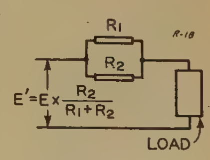

Figure 1B

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to the parallel resistance of R_1 and R_2. This is indicated in Figure 1B.

When the load consists of all four relays, the voltage across it should be 24 volts and the current will be 0.4 ampere. When it consists of one relay only, it is permitted to rise to 30 volts and the current then will be 0.125 ampere. Therefore a current change of 0.275 ampere can be accompanied by a voltage change of six volts. Since this "voltage regulation" of the voltage divider obviously is due only to the parallel resistance of R_1 and R_2 as shown in Figure 1B, it is possible immediately to write the equation

$$\frac{R_1 \times R_2}{R_1+R_2}=\frac{6}{0.275}=21.82 \text{ ohms} \tag{1}$$

The open-circuit voltage or fictitious supply voltage E' in Figure 1B is simply equal to the load voltage plus the drop occurring across the parallel combination of R_1 and R_2. With four relays operating, the load voltage must be 24 volts and the drop occurring across R_1 and R_2 equals $0.4\times 21.82 = 8.73$ volts. Therefore E', or the open-circuit voltage of the voltage divider, must be $24+8.73=32.73$. This gives a second relation between R_1 and R_2:

$$\frac{R_2}{R_1+R_2}=\frac{32.73}{230} \tag{2}$$

and introduction of this value into equation 1 immediately yields

$$R_1=153.33 \text{ ohms and } R_2=25.44 \text{ ohms} \tag{3}$$

EXAMPLE 2

In Figure 2 a Wheatstone bridge is shown operating from a supply voltage E and an indicating instrument with the resistance R_g in the bridge arm. The internal impedance of the source is considered as negligible compared to the resistances of the four arms of the bridge. It is desired to find the current through the instrument. For application of Thevenin's theorem, the branch containing the instrument is opened. The voltage e across the break will be

$$e=E\times\left(\frac{R_2}{R_1+R_2}-\frac{R_4}{R_3+R_4}\right)$$
$$=E\times\frac{R_2R_3-R_1R_4}{(R_1+R_2)\ (R_3+R_4)} \tag{4}$$

The resistance measured across the break with E short-circuited will be

$$R=R_g+\frac{R_1\times R_2}{R_1+R_2}+\frac{R_3\times R_4}{R_3+R_4} \tag{5}$$

The current flowing through the instrument will be simply $I_g=e/R$, as indicated in Figure 2B. If several instruments of similar construction (that is, same coil space) but different resistance of the coil are available, then it is clear that the maximum wattage will be developed in R_g when the latter equals the bridge resistance as measured between the points A and B with the instrument removed and E

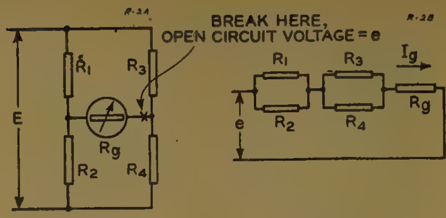

Figure 2A **Figure 2B**

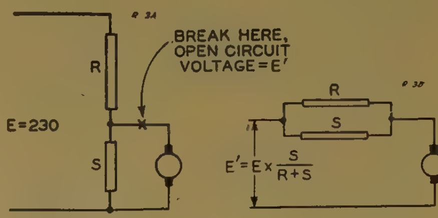

Figure 3A **Figure 3B**

short-circuited; obviously this is equal to the sum of the two terms following R_g in the preceding equation for R. In some books the erroneous statement is made that if a galvanometer near the optimum resistance is not available, the addition of a series resistance to the instrument or a shunt resistance parallel to it so that the total resistance of the combination is equal to the bridge resistance will increase the sensitivity. By inspection of the preceding equations and of Figure 2B, it is quite obvious that the wattage in a given instrument certainly cannot be increased by placing an additional resistance in series or in shunt to it.

EXAMPLE 3

The slowing down of d-c motors by means of armature control has the well-known disadvantage that a removal of the load may cause the motor to speed up to practically full speed. To avoid this, it is the usual practice to place an additional resistance across the armature. In a recent paper[1] the following instance is treated. A ten-horsepower 230-volt 1,150-rpm d-c shunt motor is to be slowed down to 45 per cent of the full-load motor speed under a condition that the load demands 34 per cent of full-load torque referred to the ten-horsepower motor. It also is required that the speed shall not exceed $66^2/_3$ per cent of the full-load speed if all load is removed from the motor shaft. In the paper the following simplifying assumptions, perfectly permissible for all practical purposes, are made: the torque is proportional to the current, the induced voltage is proportional to the speed, and under full-load condition, the IR drop in the armature is ten per cent of the line voltage.

In Figure 3A the diagram is shown. By application of Thevenin's theorem, as stated in the second form, to the branch containing the motor armature, it may be seen that so far as the armature is concerned, the effect of the voltage divider R–S is the same as if the armature were connected over a series resistance to a fixed voltage equal to the open-circuit voltage appearing across S; this series resistance is equal to the parallel combination of the two resistances R and S, since this would be the resistance measured across the break with the line terminals short-circuited; as far as the armature is concerned, the circuit shown in Figure 3A can therefore be replaced by the one given in Figure 3B.

According to the data given, the IR drop in the armature at full load is 23 volts, which means that the induced voltage at 1,150 rpm is equal to 207 volts. At $66^2/_3$ per cent of full-load speed, the induced voltage will consequently be $^2/_3$ of 207 volts, which equals 138 volts. Since it is demanded that the motor shall not exceed this speed under the no-load condition, the open-circuit voltage of the voltage divider R–S, or the fictitious supply voltage E' of Figure 3B, must not exceed 138 volts. This leads immediately to the equation

$$\frac{S}{R+S}=\frac{138}{230}=0.6 \tag{6}$$

With the assumption that the product of the current and the induced voltage becomes converted into mechanical energy, the full-load current of the motor will be

$$I_{FL}=\frac{10\times 746}{207}=36 \text{ amperes} \tag{7}$$

At 34 per cent of full-load torque, the motor current will consequently be $0.34\times 36 \doteq 12.25$ amperes. At 45 per cent of full-load speed, the induced voltage will be equal to $207\times 0.45=93.15$ volts, while the IR drop in the armature at 34 per cent of full-load current will be 34 per cent of 23 volts, which equals 7.82 volts. Therefore the armature must be supplied with a voltage equal to the sum of these two last-mentioned voltages, that is, 100.97 volts. With reference to Figure 3B, this means that the parallel combination of the two resistors R and S must have a value such that a current flow of 12.25 amperes causes a drop of voltage from 138 down to 100.97, that is, 37.03 volts. This leads therefore to the following equation:

$$\frac{R\times S}{R+S}=\frac{37.03}{12.25}=3.022 \tag{8}$$

Introducing into equation 3 the value of $S/(R+S)$ from equation 1 results in

$$R\times 0.6=3.022 \text{ or } R=5.04 \text{ ohms} \tag{9}$$

With R known, equation 1 then yields for S a value of 7.56 ohms. The small discrepancy of these values from those given in the paper is due partly to a difference in the assumed value for the full-load current and to a small amount of inaccuracy in the graphical solutions in the paper.

EXAMPLE 4

In Figure 4A, let R, S, and T represent the three phases of an unbalanced three-

phase system with the three phase voltages E_1, E_2, E_3 shown in the vector diagram, Figure 4B. Let the three impedances z_1, z_2, z_3, as shown in Figure 4A, form an unbalanced three-phase load for this system. It is desired to obtain the current flowing in z_1. Breaking the branch z_1 produces an open-circuit voltage across this break equal to the voltage between phase T and the junction of the two impedances z_2 and z_3, which are seen to be series connected between the phases R and S, that is, across the voltage E_1. The open-circuit voltage across the break will consequently be

$$E_{01}=E_3+\frac{E_1\times z_2}{z_2+z_3}=\frac{(E_3+E_1)z_2+E_3z_3}{z_2+z_3}$$

$$=\frac{-E_2z_2+E_3z_3}{z_2+z_3} \tag{10}$$

The impedance measured across the break with all phase voltages short-circuited is equal to the impedance z_1 plus the parallel impedance of z_2 and z_3, that is,

$$Z=z_1+\frac{z_2\times z_3}{z_2+z_3}=\frac{z_1z_2+z_1z_3+z_2z_3}{z_2+z_3} \tag{11}$$

The current through z_1 after closure of the break will be given by

$$I_1=\frac{E_{01}}{Z}=\frac{-E_2z_2+E_3z_3}{z_1z_2+z_1z_3+z_2z_3} \tag{12}$$

This solution is identical with the one that would have been obtained by applying Kennelly's transformation to the wye system of impedances, transforming them into a delta. The current I_1 would then be simply equal to the sum of the two currents in the two legs of the delta adjacent to phase T. The latter solution assumes that one has the transformation formulas either in his head or in a nearby handbook.

For additional examples dealing with a-c network problems, as well as a general discussion of the theorem and a proof of it, see reference 2.

EXAMPLE 5

Thevenin's theorem is not limited to the steady-state conditions but can also be used for the solution of problems involving transients. In Figure 5 let the capacitor C be discharged and then let it be connected through switch S to the voltage divider R_1–R_2. It is evident that the capacitor will finally reach a voltage equal to the open-circuit voltage existing across R_2, that is,

$$E_{C\max}=E\times\frac{R_2}{R_1+R_2} \tag{13}$$

Again, as far as the capacitor is concerned, the voltage-dividing network and the supply voltage can be replaced by a fixed voltage equal to the open-circuit voltage across R_2 as given in equation 13, and a series resistance equal to the parallel combination of R_1 and R_2. The well-known exponential relation between the instan-

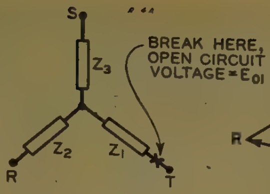

Figure 4A

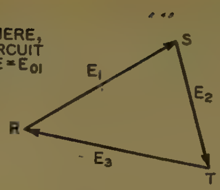

Figure 4B

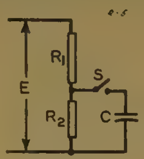

Figure 5

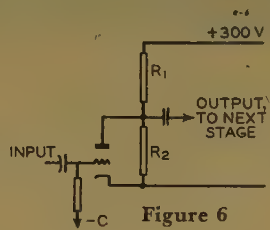

Figure 6

taneous voltage across the capacitor and time as given by

$$e=E_{C\max}(1-e^{-\frac{t}{T}}) \tag{14}$$

is therefore valid. The time constant, however, is given by

$$T=C\times\frac{R_1\times R_2}{R_1+R_2} \tag{15}$$

When making use of Thevenin's theorem for the solution of transient problems it is necessary, however, to be sure of one condition: the open-circuit voltage across the break must be independent of the frequency of the supply voltage. This condition will obviously be satisfied only when the network, exclusive of the branch in question, is made of the same type of impedances.

EXAMPLE 6

Suppose that in a resistance-coupled amplifier, grid-bias conditions are such that it would be most desirable to operate a particular stage consisting of a type 6J5 tube with a plate-supply voltage of 100 volts and a load resistance of 40,000 ohms; the high-voltage supply for the amplifier as a whole is 300 volts. Such a condition is quite often satisfied by placing a relatively heavy bleeder across the total supply, tapping the bleeder at the desired voltage, and then placing the load resistor between the tapped point of the bleeder and the plate of the amplifier tube. Since Thevenin's theorem tells us that a voltage divider acts like a fixed-voltage source and a resistance in series with it, it is obvious that we can design the bleeder to fit the individual stage. With reference to Figure 6, R_1 and R_2 simply have to be chosen so that the open-circuit voltage across R_2 equals 100 volts, which gives the relation:

$$\frac{R_2}{R_1+R_2}=\frac{100}{300} \tag{16}$$

while the parallel combination must equal 40,000, which leads to

$$\frac{R_1\times R_2}{R_1+R_2}=40{,}000 \tag{17}$$

Substitution of equation 17 into equation 16 gives $R_1=120{,}000$ ohms and $R_2=60{,}000$ ohms. This solution represents not only the highest economy obtainable as far as the amount of bleeder current is concerned, but also results in the elimination of one resistor.

It must not be assumed that the application of Thevenin's theorem makes every circuit problem an easy one. If there are numerous meshes, the opening of one branch will still make calculation of the current distribution in the remaining ones a difficult one. The preceding examples show, however, that in simpler networks its application not only will reduce the numerical work but also will aid in visualizing the influence of the various circuit parameters on the solution of the problems.

Appendix

Assume that in a network consisting of linear impedances z_1, z_2 . . . z_n and voltage sources E_1, E_2 . . . E_m, it is desired to determine the current flow in z_k. Upon opening this branch, an open-circuit voltage E_{k0} will appear across this break and the current i_k, of course, will be zero. Now suppose an additional voltage source of exactly the magnitude of the open-circuit voltage and opposing the latter is introduced across the break. This obviously will not change anything from the open-circuit condition of the branch z_k as far as the rest of the network is concerned. There is now a network with no open branches but with a new voltage source equal to E_{k0} introduced into the network. The current distribution in the network now is determined by the original m voltage sources plus the new voltage E_{k0}. But under the new condition the branch current in z_k is zero, and, according to the superposition principle, the current distribution resulting in the network from the introduction of E_{k0}, with all other voltage sources short-circuited, must be such as to cancel exactly the original current in the branch z_k. The current flowing originally in z_k therefore must be equal to a current that would be flowing if all original voltage sources were short-circuited but a voltage source equal to but opposite in polarity to E_{k0} had been introduced into the branch z_k. This proves Thevenin's theorem. Incidentally, the proof also points the way to an important extension of the theorem: while the theorem is essentially a tool for finding the current in one branch only, the current in other branches can be found by superimposing on the current distribution in the network with branch z_k open the current distribution which results from the introduction of the voltage $-E_{k0}$ in this branch, with all other voltage sources short-circuited.

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XI—Electronics—An Industry Comes of Age

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TO PREDICT the future of a new science is much like predicting the future of a new-born child. The conception date is usually a matter of record and the appearance of the "first working model" is an event. From then on, to carry the analogy farther, the thing develops and the parents or the inventer continually wonder what it will be when it grows up. During the first few years it is the most marvelous thing in the world—later, when it reaches the adolescent period, there sometimes are doubts. Usually in the end, if it has been handled properly, it reaches maturity, finds its rightful place in the world, and becomes a useful member of society. Its rate of development and the soundness of its growth depend on many things. A too rapid growth may produce "soft wood" that will not weather the storm. By expecting too much of it, or glamorizing it, one may spoil the whole thing.

War, as is well-known, hastens development tremendously. Youths leave home just kids and almost overnight they are men—hard, capable, self-reliant, and ready to take any responsibility put upon them. So it is with the sciences also. War has resulted in the development of communication, aviation, synthetic rubber, plastics, and electronics at probably 10 or 20 times the rate it would have developed in peacetime. Some of the growth is "soft wood." It is too expensive, too bulky, and in some cases too complicated. These instruments will be refined as soon as the pressure of war is gone and will find their place in our peacetime economy.

Let no man forget that electronics has played a vital role in this war—so vital in fact that it is to be hoped that the subject will be given suitable comprehensive treatment when the war is over.

There seems to be no generally accepted definition of electronics. To the engineer it may be defined as "the practical use of the flow of electrons through space." Thomas A. Edison (United States patent 307,031, 1883) observed that electricity flowed between a hot filament and a plate in an evacuated envelope when the plate was positive and that no measurable current flowed when the plate was negative. This indicated that the particles of electricity that traversed the space were charged negatively. It was not until 1891 that G. Johnstone Stoney named the particle the electron. In the meantime Fleming, Elster, Geitel, J. J. Thomson, and others had studied the flow of these particles and the latter especially had experimented with cathode-ray tubes. The cathode-ray tube, an essential part of the modern television set, thus was one of the first electronic tubes with which experiments were performed. This is true also of the photoelectric tube which is equally essential not only to television but to many other applications such as talking motion pictures, and a host of industrial instruments.

Although born in the early 1900's, electronics—meaning "the practical use of the flow of electrons through space"—developed relatively slowly until World War II caused a great burst of growth. Its place in the postwar world will depend upon its ability to do things better, cheaper, or faster than they can be done by other means.

Books have been written on the history of electronics so that obviously it cannot be covered here. Starting about 1900 experimenters too numerous to mention started turning their thoughts seriously toward the practical application of the flow of electrons. In the absence of an official "birth certificate" it may be guessed then that electronics was born in the early 1900's. Electronic-tube developments came fast and furiously. Rectifiers, photoelectric tubes, oscillators, amplifiers, cathode-ray tubes, x-ray tubes, thyratrons, ignitrons, protective gaps, current regulators, voltage regulators, the iconoscope, the electron microscope, the mass spectrometer, and other electronic devices were developed and perfected in the nation's research and engineering laboratories.

Corresponding groups of engineers and research men developed the circuits and systems for putting these devices to work. This joint effort of the electron-tube designer and the circuit engineer has of course been responsible for the development of the field of electronics.

Electronics has grown up—it has passed the glamour stage and in the future competitive market it will have to stand on its merits. It is being put to work and will be used, generally speaking, only when it can do something cheaper, faster, or better than can be done any other way. Statistics are not too accurate at the present time but it is estimated that the annual sales of electronic equipment have increased from around $275,000,000 prior to the war to well over $4,000,000,000 now.

RADIO

Radio has been and probably will be for some time the greatest field for the application of electronics. This is to be expected since it meets, to a greater degree than any other application, the requirements defined hereinbefore, namely, that it can accomplish a result cheaper, faster, and better than can be done by any other means.

The sale of broadcast receivers increased from 4,500,000 sets in 1929 to nearly 14,000,000 in 1941. The war, of course, sharply curtailed the manufacture and sale of sets after that. During this same period the average price per set came down from $136 to $30.

The sale of commercial receivers and transmitting equipment increased from about $6,000,000 in 1931 to nearly $14,-000,000 in 1939 and for 1942 it has been estimated at $550,000,000. A New York financial house estimates the 1943 total to

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be $4,000,000,000 including military equipment. The latter estimate must be considered only as a rough approximation. It serves to show principally the tremendous task accomplished by electronic manufacturers and to give at least an inkling of the progress that has been made in the development and manufacture of electronic equipment during the war.

This experience and the facilities to produce will of course be applied to peacetime products after the war.

Tubes have been developed to generate frequencies far beyond anything available before the war. This greatly relieves the crowding of the spectrum and makes room for frequency-modulation transmission, television, and peacetime applications of radar and other special forms of communication and detection.

At the time this article was written it was reported that nine commercial television stations have been licensed, 60 applications are pending, and many more are coming up. Broadcasting will most certainly be improved probably along more than one direction. Refinements will be made in the present amplitude-modulation stations and the use of frequency modulation will expand as more stations are built. Millions of home receivers now creaking to a standstill because they cannot be repaired or tubes for them cannot be obtained may never be repaired at all. Americans want the best there is and the best has not yet been made.

It is the writer's personal opinion that many of the detection devices now used in the war effort eventually will be required on all airplanes and ships just as most states require shatterproof glass in automobiles, and for the same reason—safety.

Insurance that airplanes will not run into mountains, that ships will not collide in the fog, and that they can land or dock safely in any kind of weather will give travel another increment of security.

A great deal of development will be required in this field. This equipment has mushroomed into a reality overnight. It will have to be made cheaper, smaller, lighter, and in some cases more reliable.

It would seem inevitable that a device that enhances man's sense of vision so that he can see at night, through smoke or fog, is so necessary that its continued development and use is assured. Sometimes we marvel at the human beings' ability to speak, hear, and see, and take for granted what science has done to enhance these faculties. With radio waves and electronics harnessed together we throw our voices around the earth, hear reports direct from the battlefield on the other side of the earth, see television pictures in our living rooms direct from the scene of action, and now are able to "see" objects through darkness, smoke, and fog.

Electronic control has increased production of capacitors at the Westinghouse Electric and Manufacturing Company and has reduced spoilage of critical metal foil. Even a beginner operating this winding machine will produce as many capacitors in a day as 24 operators would by hand-wound methods

ELECTRONIC HEAT

The development of high-power high-frequency tubes and equipment for radio and other war uses, coupled with unprecedented demands for production, has led to the use of high-frequency power for producing heat. For example, the war produced unheard of demands for tin plate and also the war made tin hard to get—a bad combination. It was found that if tin was fused onto the surface of a metal strip that about one-third as much tin was required as when it was applied by conventional methods. High-frequency electronic generators were used to produce heat directly in the plate by induction. Tin plate is produced by this method at speeds approaching 1,000 feet per minute. The major suppliers of tin plate are using this process and the radio-frequency power used in these plants far exceeds the total power used in all the broadcasting stations in the western hemisphere.

The manufacture of penicillin is a vitally important process. It is reported that electronic heating produces concentrated purified pencillin in 30 minutes instead of the 24 hours required by the previously used process.

Induction and dielectric heating by means of high frequency has this outstanding characteristic—the heat is generated inside the body. By properly designing the body and the power-input coupling the heat can be put where it is needed most. It will not take the place of gas and coal in domestic furnaces nor is it likely to be used in kitchens for domestic cooking or heating water. Like all other electronic applications, it will find its proper place doing specialized jobs cheaper, faster, or better than can be done by other means.

Commercial cooking, canning, and food sterilization seem to be definitely "in the wood." Dehydration of foods electronically results in more complete removal of moisture with less loss due to spoilage and rancidity. Incidentally, while electronic tubes make high-frequency induction and dielectric heating practical, it may not be so generally known that induction heating has for years been used to make electronic tubes, and that there are many other applications in tube production. In order to evacuate the tube completely of all gases it is sealed onto a vacuum system and while it is being exhausted high-frequency coils surrounding the tube heat up the internal parts and drive out gases and moisture, essentially the process used in dehydrating foods except that the frequency used in the latter process is usually higher. Rectifiers supply d-c power to the oscillators that furnish the heating current. Vacuum and temperature are measured by electronic devices. The power used in treating and testing tubes is often run through an electronic inverter and fed back into the power lines instead of being thrown away. Electronic spot and seam welders are used to weld the tube parts together, and an electrostatic precipitator is used to clean the air in the assembly room. Many electronic instruments are used to take measurements, effect automatic control of process, and for inspection and sorting of parts and materials.

Dielectric heating is certain to have an

important position in the bonding of plywood and the heating and curing of plastic materials. It has its important application when thick sections of plywood, thermoplastic, or thermosetting materials are involved. The development of thermosetting bonding materials together with the use of dielectric heating now permits the fabrication of thick sections of plywood in a matter of three to five minutes. Hours were previously required with steam or other forms of applied heat. The same is true in the heating and curing of plastics. In addition to speed, the electronic method does a more thorough and uniform job.

There are many more applications of induction heating of metals besides the tin-flow application previously mentioned. With induction heating faster and more uniform heat treating, annealing, brazing, soldering, and tempering are made possible. It is possible by proper choice of frequency and equipment to case harden the desired surface of mechanical parts such as gears and shafts and leave the base metal tough and malleable. The chief merit of electronic heating in all these cases comes back to the fact that it is possible to control it accurately and "put the heat where you want it," and quickly.

So far the application of induction and dielectric heating has been limited mostly to war jobs. After the war the field is bound to expand and applications made that now cannot be foreseen.

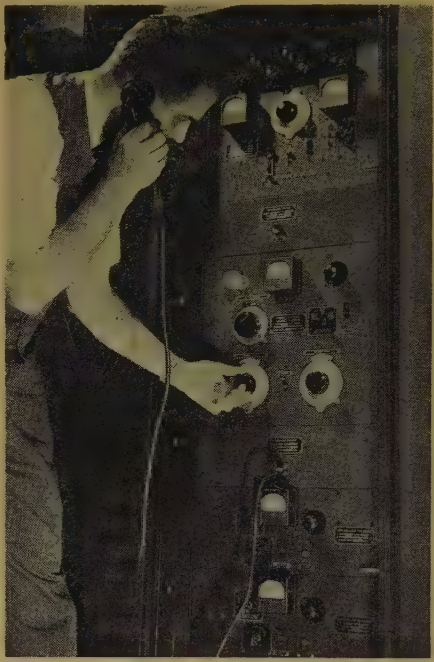
SPOT AND SEAM WELDING

The amount of sheet-metal fabrication going on in the United States is of course enormous. Sheet-metal parts have been put together with rivets, various kinds of fasteners, bolts, and so on. Soldering, brazing, and arc welding are often used. Following the invention of the ignitron, however, the use of electronically controlled spot and seam resistance welding has expanded at a rapid rate and the field is probably only scratched. By means of electronic timers the amount of current put through the weld, the exact length of time that current flows, and even the point on the cycle at which current starts can be controlled accurately. As a result, thousands of welds can be made identical so that there is very little danger of spoiling the work. A good criteria of the quality of such welding is the fact that overlapping welds or seam welding is used to make vacuum-tight joints in large electronic tubes such as metal ignitrons. Resistance welding of oil drums, tank cars, and metal airplanes is already in use.

It is to be expected that when plants convert after the war many of them will adopt electronic welders instead of drilling holes for rivets or for bolts and screws.

RECTIFICATION AND INVERSION

This is one of the largest and most important fields of application for electronics. It can be disposed of rather quickly, however, because the functions are so well known. Rectification is the conversion of a-c to d-c power and inversion is just the reverse, namely, the change of d-c power into a-c power or the change of a-c power from one frequency to another, such as changing 60 cycles to 25 cycles. Inversion is not extensively used now but probably will become more and more prominent, especially in the industries where a variable frequency is needed for variable-motor-speed control.



The operator is shown using the telephone channel on this carrier-current system. Various panel units are arranged to suit the needs of each particular installation. There are ten independent audio waves available for as many different functions

Enormous rectifier capacity has been installed during the war to supply d-c power to the aluminum, magnesium, steel, and electrochemical industries. At the beginning of 1940 all industries had about 500,000 kw of installed rectifier capacity and this was an accumulation of installations covering a period of approximately 15 years. In the three years following 1940 five times that amount or 2,500,000 kw of rectifiers have been purchased in the United States and 1,000,000 kw in Canada.

Most of the new rectifier equipment is of the ignitron type. Its merit lies in increased efficiency and reliability. Ignitron rectifiers now give and will continue to give motor generators very stiff competition.

Rectifier business alone in the United States has totaled about $120,000,000 in the last five years. Much of this has been in big units. The future will see the development of a potentially bigger market by the introduction of smaller units to reach the smaller power consumer.

CARRIER CURRENT

The term carrier current as used here means "making power-transmission wires do the double job of carrying information as well as electric power." During the war, of course, it is doubly significant because in addition to reducing costs it has saved strategic materials such as copper. The operation of protective relays with information provided by carrier current in combination with high-speed circuit breakers makes it possible to remove short circuits from systems in times as short as $^1/_{20}$ second. This not only releases system capacity but also eliminates burning out of the equipment and undesirable system disturbances. The following is an illustration of what carrier current can do. Two transmission lines, costing $6,000,000 each, were shown to have their capacity increased nearly 50 per cent as a result of installing carrier-current equipment and associated apparatus costing about $50,000. In other words, the addition of this equipment to existing lines eliminated the need for building a third line which would have cost another $6,000,000.

This business has totaled about $3,500,000 in the last five years and continued development would seem to insure its growth. The potential possibilities of sending information over existing power lines deserve serious consideration.

FURTHER APPLICATIONS

As it is recalled that electronics can convert electrical power into any desired form and can switch power accurately and quickly and do it efficiently, it is realized instantly that it can be used for all kinds of control purposes. Welding control, motor-speed control, voltage regulation, automatic synchronization, inspection, and counting are only a few.

Air cleaning is developing into a major application. The electrostatic precipitator is used for cleaning dirt, oil, and other particles from the air in precision war plants and in the motor rooms of steel mills. It is an infant in the electronic field but destined to grow up very fast when restrictive orders on critical materials are lifted.

Specialized electronic instruments like the electron microscope and the mass spectrometer give the research laboratories and industrial plants new tools to work with. The former expands microscopy into fields not previously touched and the mass spectrometer makes it possible to analyze gases and vapors with a speed and accuracy not otherwise attainable.

One fact must be reiterated—electronics is not a cure-all. It must be applied only where it can do things better, cheaper, or quicker than can be done otherwise. There are plenty of places where it can do just that.

INSTITUTE ACTIVITIES

Winter Technical Meeting Held in New York; Buffalo and Detroit Meetings Canceled

The AIEE 1945 winter technical meeting was held in New York, N. Y., January 22–26, as planned, but in compliance with the recent wartime ban on conventions the North Eastern District meeting scheduled to be held in Buffalo, N. Y., April 25–26, and the summer technical meeting scheduled for Detroit, Mich., June 25–29, have been canceled. As in previous national and District technical meetings held since Pearl Harbor, primary attention at the winter meeting was devoted to war problems.

Registered attendance was 1,718 as indicated in an accompanying tabulation. This was somewhat higher than last year's total, but considerably less than the record registration of 1,931 at the Philadelphia winter meeting in 1941.

Some 80 papers were presented at the 21 technical sessions covering a wide variety of subjects; 10 informal technical conferences on diversified subjects rounded out the program. Electric machinery was the subject of four sessions (one of which concerned machine insulation) and one conference. Three sessions and one conference were sponsored by the committee on power transmission and distribution; at the latter, wartime practices on distribution systems and their effect on system operation and future designs were discussed. Three sessions also were devoted to industrial power applications, one of which covered industrial control, and one conference, which dealt with industrial-system and apparatus voltage ratings.

Electrical applications to aircraft occupied two sessions and one conference. An all-day conference on polyethylene high-frequency cables was sponsored by the committee on communication in co-operation with the Army–Navy Radio-Frequency Cable Co-ordinating Committee. Available brief reports of the sessions and conferences are included in succeeding pages.

Following the custom of many years, the Edison Medal was presented during winter-meeting week—to E. F. W. Alexanderson (F '20) of the General Electric Company. The presentation was made at a joint evening session with the Institute of Radio Engineers. At the same session, Captain J. B. Dow of the United States Navy delivered an address on the Navy electronics program.

"Research and Its Effect on Winning the War" was the subject of an address by J. Carlton Ward, Jr., of the Fairchild Engine and Airplane Corporation, at the general session. Other features of the general session were presentation of the Alfred Noble prize to W. R. Wilson (A '43) of the General Electric Company, and presentation of Honorary Member certificate to Past President Dugald C. Jackson, professor emeritus of Massachusetts Institute of Technology. A smoker held Tuesday evening at the Hotel Commodore drew a capacity crowd of 1,668.

As is customary during winter-meeting week, the Institute's board of directors met as did many of the committees and subcommittees. Available reports of these meetings are presented in succeeding pages.

COMMITTEES

The committee responsible for the success of this year's winter meeting was headed by J. F. Fairman; other members included F. A. Cowan, W. S. Hill, M. D. Hooven, A. E. Knowlton, C. S. Purnell, C. C. Whipple, and R. J. Wiseman.

The smoker committee consisted of W. R. Van Steenburgh, *chairman;* C. F. Bolles, A. J. Cooper, T. C. Duncan, H. E. Farrer, J. B. Harris, C. T. Hatcher, E. B. King, William Jordan, E. G. D. Paterson, W. H. Rodgers, H. B. Snow, D. W. Taylor, and E. F. Thrall.

The theater- and broadcast-tickets committee included C. S. Purnell, *chairman;* G. H. Campbell, G. J. Dyktor, H. H. Heins, J. P. Neubauer, and T. J. Talley, 3rd.

Analysis of Registration at Recent Winter Technical Meetings

District	1942	1943	1944	1945
New York and foreign (3)	549	569	608	704
Middle Eastern (2)	349	417	474	463
North Eastern (1)	237	254	301	278
Great Lakes (5)	93	97	131	153
Southern (4)	68	22	80	40
Canada (10)	11	25	29	41
South West (7)	9	17	21	32
North West (9)	2	6	6	3
North Central (6)	7	6	4	1
Pacific (8)	6	6	4	3
Totals	1,331	1,419	1,658	1,718

Analysis of Registration at 1945 Winter Technical Meeting

Classification	Dist. 3	Dist. 1	Dist. 2	Dist. 4	Dist. 5	Dist. 6	Dist. 7	Dist. 8	Dist. 9	Dist. 10	Foreign	Totals
Members	570	242	396	34	127	1	27	1	3	30		1,431
Men guests	107	26	45	4	20		5	2		9	4	222
Women guests	6	6	12	2	6					2		34
Student members	17	4	10									31
	700	278	463	40	153	1	32	3	3	41	4	1,718

Research and the War Theme of General-Session Address

An address, "Research and Its Effect on Winning the War," high-lighted the general session of the 1945 AIEE winter technical meeting. It was delivered by J. Carlton Ward, Jr., president and director, Fairchild Engine and Airplane Corporation, New York, N. Y. Other features of the session were the presentation of a certificate of Honorary Membership to Past President Dugald C. Jackson, professor emeritus of electrical engineering at Massachusetts Institute of Technology, Cambridge, and the presentation of the Alfred Noble prize to W. R. Wilson (A '43), engineer's assistant, General Electric Company, Pittsfield, Mass. President C. A. Powel presided.

Drawing a distinction between research and development, Mr. Ward said that the field of research in the aircraft industry is exemplified by the work of the National Advisory Committee on Aeronautics. Related to research and development, is a third process, the formulation of technical specifications and evaluation, which Mr. Ward characterized as being predominantly a Government function.

Calling attention to the many and sometimes overlapping research agencies established to perform wartime functions, Mr. Ward discussed the current proposal to establish a national research committee to replace the many wartime agencies after the war. He also called attention to the current testimony before the Woodrum committee of the House of Representatives, declaring that not until 1944 has this great nation had in its legislative halls a single committee to formulate a top over-all policy on national defense. The question of what our postwar policy should be on research and development and other aspects of the problem are being debated.

Citing the development of military aircraft as an example, Mr. Ward told how research and development programs that in peacetime would take many years are telescoped into a matter of months during wartime. He closed his address with a discussion of the contributions of electrical engineers and the electrical industry to military aircraft and suggested some of the additional needed developments that electrical engineers might contribute. The essential substance of this address is scheduled for publication in an early issue.

D. C. JACKSON—HONORARY MEMBER

In presenting the certificate of Honorary Membership to Doctor Jackson, President Powel mentioned some of the outstanding men who have been so honored in the past, characterizing Honorary Membership as the highest honor within the Institute's power to bestow. He also called attention to Doctor Jackson's distinguished career as engineering educator and consulting engineer (*EE, Dec '44, p 449*). "Honors of this kind are always exciting," declared Doctor Jackson in his brief response; "the deep sense of appreciation of such recognition enlarges with the

years." Doctor Jackson declared that his feelings were embraced in the whole sentiment expressed by Henry Thoreau when he remarked: "If one advances confidently in the direction of his dreams and endeavors to live the life that he has imagined, he will meet with a success unexpected in common hours."

NOBLE PRIZE TO W. R. WILSON

Established for the encouragement of young engineers, the Alfred Noble prize is awarded annually to a member of one of the four national societies of civil, mining and metallurgical, mechanical, or electrical engineers, or the Western Society of Engineers. It is awarded for the best paper presented during the year by a member of one of those societies who was not over 30 years of age when his paper was published. Mr. Wilson, who received the current award for his paper, "Corona in Aircraft Electric Systems as a Function of Altitude," (*EE, Apr '44, Trans pp 189–94*), is only 25 years of age. The award consists of a certificate and a cash prize currently amounting to $300. Professor James K. Finch of Columbia University, member and past chairman of the award committee, presented the prize to Mr. Wilson. He briefly outlined the history of the prize and some of the principal achievements of Alfred Noble who was an outstanding bridge and tunnel engineer and past president of the American Society of Civil Engineers. The prize was established in 1929 and Mr. Wilson is the seventh AIEE member to receive it.

TRIBUTES TO SCOTT AND LINCOLN

In his introductory remarks, President Powel paid tribute to the late Past Presidents Charles F. Scott and Paul M. Lincoln, who died during December 1944 (*EE, Jan '45, p 41; Feb '45, p 76*). He called attention to the fact that their careers were curiously similar. Both graduated from Ohio State University; both started their life work with the Westinghouse Electric and Manufacturing Company; and both finished as heads of great electrical departments of great schools. He also mentioned the fact that it was Doctor Scott's advocacy of a headquarters building for the Founder Societies that lead Andrew Carnegie to provide a gift that made possible the erection of the Engineering Societies Building. (During winter-meeting week the Institute's board of directors passed resolutions to the memories of both men, which are published elsewhere in this issue.)

Edison Medal Presented at Joint AIEE–IRE Session

Following the custom of recent years, a joint evening session was held during the recent AIEE winter technical meeting with the Institute of Radio Engineers which was meeting concurrently in New York. During the first portion of the two-part program the 1944 Edison Medal was presented to E. F. W. Alexanderson (F '20) consulting engineer, General Electric Company, Schenectady, N. Y., for "his outstanding inventions and developments in the radio, transportation, marine, and power fields." In addition to being a long-time member of AIEE, Doctor Alexanderson is a member and past president of the Institute of Radio Engineers. During the second portion of the program, an address "The Navy Electronics Program and Some of Its Past, Present, and Future Problems," was delivered by Captain J. B. Dow of the United States Navy, Washington, D. C. AIEE President C. A. Powel presided over the first portion of the program; IRE President H. M. Turner (M '20) over the second.

John Grotzinger (A '24) Goodyear Tire and Rubber Company, Akron, Ohio, chairman of the committee on industrial power applications who presided at several technical sessions, discusses the program with Herbert Speight (M '21) Westinghouse Electric and Manufacturing Company, New York, N. Y., former committee chairman

Preceding the award of the medal, Chairman Karl T. Compton of the Edison Medal committee outlined the history of the medal and R. C. Muir, long-time associate of Doctor Alexanderson, spoke on the human side of the medalist that is not so well known.

Doctor Compton told how a group of friends and associates of Edison established the medal at the turn of the century to commemorate the great inventer's contributions. Funds for a memorial were raised from many contributors, and, following a period of several years of uncertainty with regard to the best form the memorial should take, the plan of awarding an annual gold medal was adopted in 1908. Beginning in 1909, the medal has been presented every year except two. It is awarded by a committee consisting of 24 members for "meritorious achievement in electrical science, electrical engineering, or the electrical arts."

In his talk, Doctor Muir stressed the medalist's love of people, especially young people who work with him. Quoting Doctor Alexanderson's own statement that: "The relationship between the older and younger generations should be one which is not characterized as boss and assistant, but one of teamwork where the younger generation supplies the knowledge in latest technical development, and the older generation contributes experience and imagination," Doctor Muir added his own observation that "he carries out these principles whole-heartedly."

In his response after President Powel had presented the medal and certificate to him, Doctor Alexanderson paid tribute to Edison as a symbol of American inventiveness that still stands out alone. He told how more than 40 years ago he had emigrated from Sweden to America, attracted by the fame of such names of Edison and Steinmetz and how he found all that he had hoped for in inspiration, opportunity, and friendly guidance. Devoting the major part of his address to invention, he predicted that during the postwar years "Invention will not solve all our social problems, but it will be a major factor as it has been in the past."

The essential substance of these addresses is scheduled for presentation in an early issue.

THE NAVY'S ELECTRONIC PROGRAM

To indicate the magnitude of the Navy's electronic program, Captain J. B. Dow, in his address following the Edison Medal presentation, said that during the calendar year 1944 more than $1,300,000,000 worth of radio, radar, and sonar equipment was delivered to the Navy, exclusive of the large amount of equipment purchased directly from the Army. He reported also that for the fiscal year 1945 a total of approximately $80,000,000 has been appropriated by the Navy for research and development in the electronic field. The intensity of wartime research in electronics has advanced the art by many years, he said, and, from such observations as we have been able to make, American science and industry have met our needs as well as the Germans have met theirs, and considerably better than the Japanese. He cautioned, however, that we must at least maintain our present position; and to shorten the war, we must improve it.

Calling attention to the importance of the work already done in standardization of component parts of electronic equipment, Captain Dow outlined the great amount of work still to be done in this field and indicated some of the problems still to be solved. "The production of dependable and easily maintained equipments with the least component complexity is greatly contingent upon the early selection and application by the equipment-design engineer of standard approved items for the various required components during the conception, research, and development phases," he declared, adding that, while the prime effort must be directed toward immediate war problems, it is also important that plans for postwar standardization programs be begun.

Captain Dow devoted the concluding part of his address to a discussion of some of the problems that may arise in the postwar development of radar and a proposed pool of radar patents to overcome some of those difficulties. An article embracing the major portion of his address appears elsewhere in this issue.

Publication of Papers to Continue During Ban on Meetings

Although no AIEE national nor District meetings may be held in the near future because of the current wartime restrictions, publication of technical papers and discussions will continue as previously planned, insofar as they are available. Therefore, members intending to write papers for presentation should proceed with the preparation of their manuscripts and submit them to Institute headquarters as soon as completed, just as they would have done if the meetings were to be held. Likewise, those wishing to discuss papers should prepare their discussions in written form and, instead of taking them to the meetings for oral pres-

entation, should mail them to headquarters.

According to present plans, abstracts of papers available in pamphlet form for general distribution will be published in *Electrical Engineering*, as heretofore (the next group of abstracts is scheduled for the April issue). Those wishing to discuss the papers should obtain pamphlet copies from Institute headquarters and submit their written discussions as soon thereafter as possible. Both paper and discussion manuscripts should be addressed to the attention of the secretary of the technical program committee, as usual.

Cancellation of the meetings requires no change in publication policy, and therefore the publication of papers and discussions will continue as before. Technical papers will be published in the Transactions sections of the monthly issues of *Electrical Engineering* insofar as budget limitations and wartime restrictions on the use of paper permit; papers for which space is not available in the monthly issues, plus all approved discussions, will be published in the two semiannual "Supplements to Electrical Engineering—Transactions Section." All approved technical papers and discussions will be published in the *Transactions* volume as in the past.

Industrial Voltage Ratings Discussed in Conference

Points of view of the equipment manufacturers and users and of the power companies in regard to industrial-system and apparatus voltage ratings were thoroughly aired at one of the conferences held during the recent AIEE winter meeting. The conference was one of several sessions and conferences sponsored by the committee on industrial power applications, and John Grotzinger (A '24), chairman of that committee, presided.

The voltage-standardization work being conducted jointly by the Edison Electric Institute and National Electrical Manufacturers Association was summarized by H. P. Seelye (F '43) of The Detroit (Mich.) Edison Company. One of the purposes of that joint study, he said, is to set up operating-voltage variations within which the power industry now is operating or can be expected to operate. He emphasized that well-regulated systems should not and do not have spreads as great as plus or minus 10 per cent.

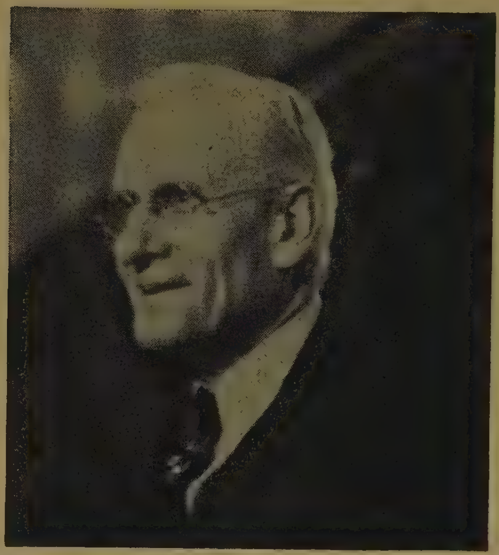
T. C. Duncan (A '30) of the Consolidated Edison Company of New York said that that company supplies service at 120–208 volts to all customers; those requiring different voltages must provide the necessary conversion equipment. In large installations within network areas, the secondary network is run into the customer's premises.

The importance of voltage regulation in modern industrial systems was stressed by D. L. Beeman (M '43) of the General Electric Company, Schenectady, N. Y. He described the characteristics of different plant layouts, and discussed allowable voltage deviations from the standpoint of the equipment manufacturer.

Various aspects of the subject from the point of view of the equipment user were presented by F. W. Cramer (M '40) Carnegie-Illinois Steel Corporation; R. T. Woodruff, Aluminum Ore Company; K. K. Falk, Bendix Aviation Corp.; and John M. Webb (A '35) Eli Lilly Company. In the absence of Messrs. Falk and Webb, Chairman Grot-

In Memoriam

CHARLES FELTON SCOTT



THE directors of the American Institute of Electrical Engineers record with profound sorrow the death of Charles Felton Scott, president of the Institute in 1902–03, Edison Medalist in 1929, and widely honored for his leadership in the engineering profession. He was born at Athens, Ohio, on September 19, 1864, and attended Ohio State and Johns Hopkins Universities, receiving the bachelor of arts degree from the former in 1885. Early in his career he became associated with the Westinghouse Electric and Manufacturing Company and contributed notably to that company's pioneer developments in a-c power and machinery and to its leadership in educational activities. He continued with the Westinghouse company as consulting engineer until 1911, when he accepted the professorship of electrical engineering at Yale University. Doctor Scott retired from active professorial duties in 1933, but continued until the time of his death his lifelong efforts on behalf of the organized life of the engineering profession.

As president of the Institute in 1902–03, Doctor Scott stimulated Section growth and pioneered in the establishment of Student Branches. His inspiring advocacy of a united-building program for the Founder Societies was largely instrumental in securing from Andrew Carnegie a gift of $1,500,000 for this purpose. Doctor Scott also served as president of the Engineers' Society of Western Pennsylvania in 1904, as chairman of the power-transmission section of the International Electrical Congress at St. Louis in 1904, as president of the Society for the Promotion of Engineering Education in 1921–23, as chairman of the Engineers' Council for Professional Development in 1935, and as president of the National Council of State Boards of Engineering Examiners in 1938.

In addition to the Edison Medal conferred by the Institute in 1929, he was the recipient of the Lamme Medal of the Society for the Promotion of Engineering Education in 1930. During his career he received many academic honors, including the degrees of master of arts, Yale University; doctor of science, University of Pittsburgh; and doctor of engineering, Stevens Institute of Technology.

Resolved: That the board of directors of the American Institute of Electrical Engineers upon behalf of the membership hereby expresses its profound sorrow at Doctor Scott's death and its enduring gratitude for his inspiring leadership of the profession at large.

And be it further resolved that these resolutions be recorded in the minutes and be transmitted to members of his family.—*AIEE Board of Directors, January 25, 1945.*

zinger read their prepared talks. Some of the speakers considered the problem more as one of establishing standard voltage spreads than that of setting up specific voltage ratings. Regulators were considered justified in large plants, and the need for pole-mounted regulators for use near large plants was indicated.

In the discussion that followed, some of the manufacturers representatives called attention to the difficulty of manufacturing equipment to operate satisfactorily over the widest voltage spreads found in practice, and urged that the supply system be designed so as to provide rated voltage and thus permit the equipment to operate at highest efficiency and best performance. All agreed that best results will be achieved through the co-operation of equipment users and manufacturers and the power companies.

Silicones as Electrical Insulation Interests Session

The physical characteristics, dielectric qualities, and behavior under different operating conditions of the various silicones described in two technical papers presented at the session on machinery insulation held January 23, during the winter technical meeting, were subjected to keen discussion. The authors, T. A. Kauppi (A '44) of the Dow Corning Corporation and S. L. Moses (M '44) of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. (Organo-Silicon Compounds for Insulating Electric Machines), L. R. Hill, G. L. Moses, and J. De Kiep (M '43) all of the Westinghouse Company (The Application of Silicone Resins to Insulation for Electric Machinery), impressed upon their hearers the fact that much needs to be done and trial installations need to be made before the limitations which must be placed on this new insulation compound are learned. There was general accord on the fact that silicones, if properly applied, will add materially to the operating-temperature range of electric equipment and that designers should find use for the resins in the near future.

The moisture-resistant quality of the new insulation was the feature which particularly interested an officer from the Army Signal Corps and a representative of one of the major oil companies. Superiority in moisture resistance over materials in common use is claimed for the silicones, but it is not applicable on coils already wound with other insulating materials. (*A. M. de Bellis, chairman, AIEE subcommittee on insulation resistance.*)

Diversified Program Session on Instruments and Measurements

The improvement of current-transformer characteristics by the superposition of a harmonic frequency on the core, a new telemetering system based on frequency differences, the study of relay operation by electronic circuits, and a portable high-voltage insulation-testing apparatus were the subjects of papers presented to an audience of more than 125 at the instruments and measurements session held Wednesday afternoon, January 24, during the winter technical meeting.

In the discussion which followed presentation of "Orthomagnetic Bushing Current Transformer for Metering," by A. Boyajian (F '26) and G. Camilli (F '43) of the General Electric Company, Pittsfield, Mass., it was pointed out that the paper represented the application of a theoretical principle to the practical improvement of current-transformer characteristics and the method opened the way for a wider diversity of high ratios without exceeding permissible limits of accuracy. Attention was drawn to the fact that 720 cycles appeared to be the upper frequency which produced favorable results. Participating in the discussion were: F. B. Silsbee (F '42) of the Bureau of Standards, Washington, D. C.; E. C. Wentz (M'42) and C. A. Woods, Jr. (A'37) Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.; and Stuart D. Moreton (A '43) General Electric Company, Philadelphia, Pa.

The paper, "A Modulated Frequency System of Telemetering," by H. E. Renfro and A. P. Peterson (A '32) of the Control Corporation, Minneapolis, Minn., was characterized by Perry Borden (M '19) of the Bristol Company, Waterbury, Conn., as a valuable contribution to telemetering, describing as it did a practical operative system involving a new principle in the conversion of instrument indications into frequency. Mr. Borden recalled also that the "Report on Telemetering, Supervisory Control, and Associated Circuits" prepared in 1940 by the subcommittee on telemetering, of which he was chairman, mentioned the use of frequency systems.

F. W. Atkinson (M '37) and R. B. Taylor, of the TAKK Corporation, Newark, Ohio, authors of "A Portable Instrument for Measuring Insulation Resistance at High Voltage," were congratulated on having devised a new portable apparatus for direct-voltage testing in the field, and the discussers stated that the apparatus also enables the obtaining at high voltage of absorption–current–time characteristics of insulation. The paper was discussed by R. L. Webb (M '35) of the Consolidated Edison Company of New York, Inc., New York; J. S. Johnson (A '36) of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.; and T. B. Whitson (A '28) of the James G. Biddle Company, Philadelphia, Pa. (*Chester L. Dawes, chairman, AIEE committee on instruments and measurements.*)

Board of Directors Meets During Winter Technical Meeting

The North Eastern District technical meeting scheduled to be held in Buffalo, N. Y., April 25–26, 1945, and the summer technical meeting to be held in Detroit, Mich., June 25–29, 1945, were canceled by the AIEE board of directors at its regular meeting at Institute headquarters, New York, N. Y., January 25. This was in accordance with the decision of the Office of War Mobilization and Reconversion calling for a cessation after February 1 of all group meetings drawing an attendance of over 50 persons using other than local transportation, unless special permission is granted by the War Committee on Conventions who must be convinced that the war effort will suffer if the meeting is not held.

The question of holding the Pacific Coast technical meeting, scheduled for Seattle, in August 1945, was referred to the executive committee for action. The Southern District technical meeting, scheduled to be held in South Carolina in November 1945, was postponed. Decision regarding time and place of the annual business meeting of the Institute was referred to the executive committee with power.

Memorial resolutions were adopted for

A. C. Monteith (M '40) Westinghouse Electric and Manufacturing Company, Director T. G. Le Clair (F '40) Commonwealth Edison Company, President C. A. Powel (F '41) Westinghouse Electric and Manufacturing Company, and C. B. Kelley (M '30) Kansas City Power and Light Company, photographed during the winter technical meeting. Mr. Monteith is chairman of the Standards committee

Past President Charles F. Scott, who died on December 17, 1944, and Past President Paul M. Lincoln, who died on December 20, 1944, as printed elsewhere in this issue.

The board adopted a resolution, offered by the finance committee, which will continue for the year beginning May 1, 1945, the provision that has been in force for several years for an exchange allowance, corresponding to the difference between the New York exchange value and the normal par value of the payment, on payment of membership dues and membership subscriptions to or purchases of Institute publications amounting to two dollars or over, such allowance not to exceed 60 per cent of the bills payable, and to be applicable to the appropriation for each Section in any country affected.

Continuing a policy that has been in effect for two years and otherwise would have expired on January 28, 1945, the board adopted a resolution "that all enrolled Students of the Institute who enter the armed services or the Merchant Marine shall have the option of continuing their Student enrollment during their war service upon payment of the regular annual fee of three dollars, with all publications being sent to their permanent address; or of being inactive Student members, without payment of the fee and without publication service. In either case, enrolled Students will, upon severance from war service, have the same status as if they were then college students or had been graduated from college on that date, depending on whether they continue their education or not—this policy to be in effect for a period of two years."

The board approved recommendations of the Standards committee for the appointment of AIEE representatives as follows:

W. A. Brecht to succeed F. B. Powers as AIEE representative on the Sectional Committee on Railway Motors C35, and W. S. H. Hamilton as chairman of this Sectional Committee, succeeding former Chairman F. B. Powers.

Robert D. Evans on the proposed Sectional Committee on Methods of Measuring Radio Noise.

E. M. Callender to replace Wray Dudley, resigned, on Sectional Committee on Electric Welding Apparatus C52.

J. E. Hobson to replace R. E. Johnson, resigned, on Sectional Committee on Electric Water Heaters C72.

W. L. Heard as chairman of Sectional Committee on Graphical Symbols and Abbreviations for Use on Drawings Z32, to succeed H. W. Samson, resigned.

Chairman I. Melville Stein of the AIEE committee on collective bargaining and related matters, present by invitation, presented the report of that committee, dated January 9, 1945. The board approved the report in principle and authorized the committee to publish it. An additional appropriation was granted to the committee toward the cost of preparation of a proposed manual of information on the subject.

Upon recommendation of the vice-president of the Middle Eastern District (number 2), the Toledo and Dayton Sections, and the Sections committee, the board voted to transfer Allen County, Ohio, from the territory of the Toledo Section to that of the Dayton Section.

Proposed amendments to the constitution, authorized by the board of directors on June 29, 1944, and rewritten in a form which has been approved by legal counsel, were reported by the committee on constitution and bylaws, and were approved by the board for sub-

In Memoriam

PAUL MARTYN LINCOLN

PAUL MARTYN LINCOLN, Institute president 1914–15, died on December 20, 1944 at the age of 74. He was born at Norwood, Mich., January 1, 1870, and attended Western Reserve and Ohio State Universities, receiving the mechanical engineer degree in electrical engineering from Ohio State in 1892. Prior to graduation from Ohio State University, he was employed by the Short Electric Company of Cleveland. Immediately after graduation he entered the testing department of the Westinghouse Electric and Manufacturing Company at East Pittsburgh, Pa.

Mr. Lincoln was employed as electrical superintendent in charge of powerhouse operations by the Niagara Falls Power Company from 1895 to 1902. In 1902 he returned to the employ of the Westinghouse Company and for two years worked as an application engineer in the early introduction of the single-phase interurban and main-line railroad electrification. In a reorganization of the engineering department of the Westinghouse Company in 1904, he became power division engineer. In this position he was responsible for the design of large a-c and d-c rotating machinery and switchboards. Mr. Lincoln was appointed a general engineer on electric-power stations and transmission in the general engineering department in 1910 and served in this capacity until 1919. During a part of this same period from 1911 to 1915, he also served as head of the engineering school in the University of Pittsburgh and in connection with this work developed a new type of demand meter. In 1919 Mr. Lincoln resigned from the Westinghouse Company to become consulting engineer for the Lincoln Electric Company of Cleveland, Ohio, and in 1922 he was appointed director of the school of electrical engineering at Cornell University. He served in this capacity until his retirement in 1939.

Mr. Lincoln organized the Lincoln Meter Company, Ltd., of Toronto, Canada, and the Lincoln Meter Company, Inc., of Springfield, Ohio, to develop commercially his demand-meter patents. This work was highly successful in Canada and his type of demand meter became the standard throughout Canada. In 1938 he organized the Therm-Electric Meter Company in Ithaca, N. Y., to develop commercially a new form of thermodemand meter.

Mr. Lincoln was a member of several scientific and engineering societies, and of the board of management of the World's Congress of Engineers (1923–25). In 1902 he received the John Scott Medal Award from the City of Philadelphia upon the recommendation of the Franklin Institute for his invention of the synchroscope.

Mr. Lincoln served the Institute as manager (1906–09); as vice-president (1909–11); and as president (1914–15). He was very active on Institute committees, serving on the papers, and meetings and papers (now technical program) committees; on the executive, Sections, and law committees; and on many technical committees as power stations, protective devices, transmission and distribution, electric machinery, standards, instruments and measurements, Edison and Lamme Medal committees, and the board of award of the John Fritz Medal.

Resolved: That the board of directors of the American Institute of Electrical Engineers upon behalf of the membership hereby expresses sincere appreciation of Mr. Lincoln's many contributions during his membership of 46 years to the development of Institute activities and his service to the engineering profession as a whole and deepest regret at his death.

And be it further resolved that these resolutions be entered in the minutes, and copies be transmitted to members of his family.—*AIEE Board of Directors, January 25, 1945.*

mission to the membership for vote by letter ballot.

Upon recommendation of the committee on constitution and bylaws, amendments to the bylaws were adopted, as follows:

Section 65. In the list of technical committees, the title of the committee on electrical machinery was changed to "committee on electric machinery" (to conform to the American Standard "Definitions of Electrical Terms").

Sections 51–57, 60, 64. Wording changed in accordance with the approval by the board of directors, on June 29, 1944, of a recommendation of the committee on Student Branches for an amendment to the bylaws covering the use of the designation "Student member" instead of "enrolled Student."

T. H. Morgan and I. Melville Stein were reappointed Institute representatives on the council of the American Association for the Advancement of Science for the calendar year 1945.

H. S. Osborne was appointed an AIEE representative on the Hoover Medal board of award for the six-year term beginning in May 1945, to succeed F. M. Farmer, whose term will expire at that time.

The board approved changes in articles *C*2 and *C*5 of the constitution of the American Standards Association as submitted to the member-bodies of the association under date of December 27, 1944.

Report was made of the following actions on applications by the executive committee as of December 8, 1944: 12 applicants transferred to the grade of Fellow and 31 transferred to the grade of Member; 18 applicants elected to the grade of Member and 100 elected to the grade of Associate; 436 Students were enrolled.

Recommendations of the board of examiners, adopted at meetings on November 16 and December 21, 1944, and January 18, 1945, were approved. Upon recommendation of the board of examiners, the following actions were taken: 8 applicants were transferred to the grade of Fellow; 92 applicants were transferred, 66 were elected, and one was reinstated to the grade of Member; 311 applicants were elected to the grade of Associate; 362 Students were enrolled.

Appropriation expenditures were reported by the finance committee, as follows: $28,473.83 in November 1944, $25,978.92 in December 1944, and $25,566.53 in January 1945.

Those present were:

President—C. A. Powel, East Pittsburgh, Pa.

Past Presidents—N. E. Funk, Philadelphia, Pa.; H. S. Osborne, New York, N. Y.

Vice-Presidents—C. B. Carpenter, Portland, Oreg.; M. S. Coover, Ames, Iowa; J. F. Fairman, New York, N. Y.; J. M. Gaylord, Los Angeles, Calif.; W. J. Gilson, Toronto, Ont.; R. T. Henry, Buffalo, N. Y.; C. W. Ricker, New Orleans, La.; R. W. Warner, Austin, Tex.; W. E. Wickenden, Cleveland, Ohio.

Directors—P. L. Alger, Schenectady, N. Y.; C. M. Laffoon, East Pittsburgh, Pa.; T. G. LeClair, Chicago, Ill.; F. R. Maxwell, Jr., Pensacola, Fla.; M. J. McHenry, Toronto, Ont.; C. W. Mier, Dallas, Tex.; S. H. Mortensen, Milwaukee, Wis.; D. A. Quarles, New York, N. Y.; W. R. Smith, Newark, N. J.

National Secretary—H. H. Henline, New York, N. Y.

Trend Toward High-Speed Relays Seen at Generator Conference

A conference session on generator protection was held as a part of the AIEE winter technical meeting, at which the following three papers were presented by members of the working group on this subject:

"Generator Differential Protection," by W. K. Sonnemann (M '43), Westinghouse Electric and Manufacturing Company, Newark, N. J.

"Generator Protection," by E. L. Michelson (A '37), Commonwealth Edison Company, Chicago, Ill.

"Generator Field Protection," by H. F. Lindemuth (M '41), Consolidated Edison Company of New York, Inc., New York, N. Y.

The session was called to order by W. A. Lewis (M '39), chairman of the relay subcommittee of the AIEE committee on protective devices, who outlined the aims of the subcommittee and the part that these conference sessions played in the development of the committee's program. He then turned the meeting over to J. C. Bowman (A '40).

Mr. Sonnemann's presentation favored simultaneous tripping in case of fault and saw a trend toward one-cycle relays to gain five cycles over the time required with six-cycle relays. The practice of the Commonwealth Edison Company of Chicago, Ill., was reviewed by Mr. Michelson, who indicated that an effort is made to keep the generators on the line as long as possible. The system is such that there is little possibility of having through fault current. He indicated that the company's practice favors operating machines as induction generators in case of loss of field, rather than tripping, provided the time of such operation is not unduly long. Mr. Lindemuth's paper described the insulation of field-protective relays on machines of the Consolidated Edison Company of New York. He pointed out that ten years ago the only field protection installed on this system consisted of two incandescent lamps connected in series across a field circuit with their mid-point grounded. Installations now have been made of undervoltage and undercurrent protection, field-ground indication, and field-temperature indication.

During the discussion following the presentation of the papers, a plea was made for more detailed information on failures, because of the lack of information on damage to machines as related to relay times. Neutral resistance was declared to be of value in reducing iron burning. A view was expressed that generators should be cleared from the system as rapidly as possible in order to minimize damage to the machine, and that the system should be designed for operation with the loss of any unit. Other problems encountered by the various companies represented, together with the solutions of these problems, were described.

The enthusiasm shown by the participants in the discussion indicated that the subject was of vital interest to the industry at large, and that the subject was well chosen for a conference session.

Four Sessions Sponsored on Transmission and Distribution

Three regular technical sessions and one conference session on wartime practices on distribution systems and their effect on system operation and future designs were sponsored at the winter meeting by the committee on power transmission and distribution.

WARTIME PRACTICES

At the conference session, the history of interruptions in the past five years on the system of the Duquesne Light Company, Pittsburgh, Pa., for various kinds of service, was related by E. V. Hill in a paper, "Analysis of Customer-Service Interruptions As a Means of Determining Acceptability of Designs for Methods of Supply." Mr. Hill estimated that 70 per cent of the outages on the Duquesne system occurred on the distribution circuits. The number of outages increased as the transmission voltage decreased, with very few recorded on the company's high-voltage transmission lines.

The changes wrought by wartime stringencies in both system and industrial substation design were described by N. G. Larson (A '35) of the Commonwealth Edison Company, Chicago, Ill., in his paper, "Distribution Substation Design in Chicago as Influenced by Wartime Conditions." Chief among the modifications was the dropping of primary busses from system substations. In some instances bus-voltage regulation was substituted for individual feeder-voltage regulation. Mr. Larson also mentioned the need for economy in future design.

A paper by L. M. Olmsted (M '39) of the Duquesne Light Company studied the "Limiting Effect of Auxiliary Equipment, Such as Connectors and Clamps Upon the Ratings of Overhead Conductors." According to Mr. Olmsted's studies, clearance and connectors do limit the ratings of overhead conductors, particularly suspension clamps. He suggested that suspension and strain clamps be redesigned to reduce magnetic heating. He reported the most satisfactory results with connectors of the twisted-sleeve type and expressed the opinion that compression connectors hold much promise for the future.

E. W. Oesterreich (F '42) of the Duquesne Light Company presented the final paper of the session, "Analysis of Availability of Equipment as Affected by Prearranged Maintenance Requirements and Capacity Limitations Resulting From Equipment Failure."

These papers and the ensuing discussion indicated that some practices adopted as wartime expedients would remain permanently. Others, however, will be replaced, as originally intended, by reversion to former practices or development of improved procedures. E. W. Oesterrich and E. K. Huntington (M '35) presided jointly at the conference.

The technical sessions sponsored by the committee were on cables and corrosion at which R. J. Wiseman (F '27) presided; on lightning and protective relaying and on supervisory control and stability at both of which H. E. Wulfing (M '23) chairman of the committee on power transmission and distribution, presided.

CABLES AND CORROSION

Four papers were presented at the session on cables and corrosion. First of these was paper 45-58, "The Dielectric Strength and Life of Impregnated Paper—IV," by J. B. Whitehead (F '12) and J. M. Kopper, III (A '34), the fourth in a series of papers reporting the results of investigation by Doctor Whitehead and his associates at Johns Hopkins University into the relationship between kind of oil and density of paper on the dielectric strength, power factor, and capacitance of the dielectric—oil-impregnated paper.

Further confirmation was given that the voltage breakdown starts in an oil channel or the gap in the paper tape; also that low-density paper gives a higher breakdown voltage than high-density paper, because the lower specific inductive capacity of low-density paper results in a lower electric stress on the oil channel, and, therefore, a higher voltage is required to break down the oil channel. The paper offers an explanation of the mechanism of voltage breakdown, power factor, and capacitance as related to paper density in terms of fundamental conductance phenomena in insulating oils.

Paper 45-60, "The Galvanic Corrosiveness of Soil Waters," presented by H. S. Phelps (A '21) and F. Kahn (A '36), reported the results of attempts to determine how the *pH* value of soil waters influence the corrosiveness of copper, lead, iron, and carbon when each acts as an anode or cathode. Their findings indicate that galvanic corrosiveness on lead, copper, and iron is generally more severe for low *pH* than for high *pH*. The relationship between static potential of each of the four elements and *pH* and the relationship between the polarization potential of each of the four elements and *pH* are given.

C. M. Sherer (A '39) and K. J. Granbois (A '31) in paper 45-61, "Study of Alternating Sheath Currents and Their Effect on Lead-Cable Sheath Corrosion," reported on an investigation conducted by the Safe Harbor Water Power Corporation as a result of cable-sheath failures which appeared to be caused by a-c electrolysis. A description of the conditions present when failures occurred and the laboratory studies carried out to duplicate the sheath corrosion is given in the paper. The authors concluded that the cable failures were the result of rectified induced alternating sheath currents in combination with galvanic currents plus possibly a small amount of chemical action. It was suggested that in new installations of single-conductor lead cables in underground-duct systems caution be observed to guard against the effect of water seeping into the ducts. A warning was given regarding the use of laboratory data to explain field results on a time basis.

Paper 45-59, "Electrolysis and Corrosion of Underground Power-System Cables," which was presented by L. J. Gorman, gave a very complete yet concise review of the causes for electrolytic corrosion and galvanic corrosion (as distinguished from corrosion from currents flowing from the metallic sheath), chemical corrosion, the results of surveys which show the relationship between duct resistance and rate of cable failure and suggested methods for reducing the number of cable failures by electrolysis mitigation, cathodic protection, protective coverings over the cable and the practices of coating the cable with grease and flushing ducts.

LIGHTNING AND PROTECTIVE RELAYING

The three papers presented at the session on lightning and protective relaying roused a lively discussion.

Paper 45-67, "Impedances Seen by Relays During Power Swings With and Without Faults," by Edith Clarke (M '33) presented a simple method of constructing charts of the system impedances seen by distance relays during power swings. These charts provide a simple means for determining the setting of distance relays. Power swings during all types of unsymmetrical faults, as well as during symmetrical system conditions, were considered. The paper was discussed by L. F. Kennedy (M '39) and A. R. van C. Warrington (A '31) General Electric Company, Schenectady, N. Y.; E. W. Kimbark (M '35) Northwestern University, Evanston, Ill.; F. C. Poage (M '38) Ebasco Services, Inc., New York, N. Y.; and E. L. Michelson (A '37) Commonwealth Edison Company, Chicago, Ill.

Paper 45-18, "Lightning Investigation of 132-Kv System of American Gas and Electric Company," by I. W. Gross (M '40) and G. D. Lippert (A '38) presented data on lightning conditions at major stations in relation to the number of disturbances, lightning currents, attenuation, effect on multiple lines, rate of voltage change, improvements of ground wires, and other factors. The paper was discussed by J. H. Hagenguth (A '28) General Electric Company, Pittsfield, Mass., and P. L. Bellaschi (F '40) Westinghouse Electric and Manufacturing Company, Sharon, Pa.

Paper 45-26, "Lightning Investigation on Transmission Lines—VIII," by W. W. Lewis (F '38) and C. M. Foust (M '31) continued the lightning investigations of the authors and presented data relating to rate change of voltage, maximum voltage and current in ground wires and arresters. The paper was discussed by J. H. Hagenguth and E. D. Sunde (A '36) Bell Telephone Laboratories, Inc., New York, N. Y.

SUPERVISORY CONTROL AND STABILITY

The third session consisted of four papers. Paper 45-77, "The Combination of Supervisory Control With Other Functions on Power-Line Carrier Channels," by R. C. Cheek (A '42) and W. A. Derr (A '43) outlined the conditions that must be satisfied for proper operation of the standard supervisory control system, and explained difficulties and methods of co-ordinating supervisory with other functions of power-line carrier channels.

Paper 45-7, "Supervisory Control for New Chicago Subway," by W. A. Derr (A '43), C. J. Buck, and J. A. Stoos, described the Visicode supervisory control equipment used to control power for the subway and designed to furnish all necessary information to the dispatchers in as small a space as feasible. The paper was discussed by C. E. Parks (A '40) Public Service Company of Indiana, Indianapolis.

J. E. Housley (F '43) Aluminum Company of America, Alcoa, Tenn., H. B. Wolf (M '37) Duke Power Company, Charlotte, N. C., and J. H. Lampe (M '26) University of Connecticut, Storrs, in the lobby between sessions. Mr. Housley is a past AIEE director, and chairman of the committee on electrochemistry and electrometallurgy

Paper 45-78, "Power-Line Carrier Channels," M. J. Brown (M '44) discussed the attenuation of high-frequency currents in power-line carrier channels on the basis of theory and practical measurements. The paper was discussed by R. N. Stoddard (M '34), Westinghouse Electric and Manufacturing Company, Bloomfield, N. J.

Paper 45-13, "Improving Stability by Rapid Closing of Bus-Tie Switches," by E. W. Kimbark, outlined calculations showing that stability could be increased on high-voltage transmission systems under certain conditions by closing high-voltage bus-tie breakers simultaneously with the opening of the circuit breakers on the faulty lines. The paper was discussed by E. L. Michelson (A '37) Commonwealth Edison Company, C. E. Parks, and E. K. Huntington, Rochester (N. Y.) Gas and Electric Corporation. (*H. E. Wulfing, chairman, AIEE committee on power transmission and distribution.*)

Power-Station Auxiliaries Discussed at Conference Session

A conference was held during the AIEE winter technical meeting for the purpose of obtaining an informal cross section of existing practice in the supply of power for auxiliaries in steam-electric stations. A. J. Krupy (M '33) chairman of the committee on power generation presided.

The conference consisted of the presentation of a number of prepared papers, followed by a period for discussion. The first paper, by J. B. McClure (A '29) and Hal Gibson of the General Electric Company, Schenectady, N. Y., was intended to suggest how standard equipment may be used in the modern power plant to provide a satisfactory auxiliary power system. The following general conclusions of the authors were presented as a guide in planning a system:

1. Individual power supply for each boiler should be considered.
2. Power supply from generator terminals is being increasingly used.
3. The preferred system voltages are 460 and 2,400 volts.
4. It is economical to use 460 volts for transformer capacities up to and including 1,000 kva.
5. Dual-voltage systems using 2,400 and 460 volts should be considered for transformer capacities of 1,500 kva and up.
6. In the dual-voltage system, motors up to 200–250 horsepower can be operated economically at 460 volts.

The modern trend toward all-electric drives for auxiliaries was reviewed in a paper by W. R. Brownlee (M '38) and J. A. Elzi (M '38) of the Commonwealth and Southern Corporation, Jackson, Mich., who reached the following conclusions:

1. Experience over a number of years, including that with 500,000 kw of modern 850-pound 900-degree steam plants, has demonstrated the reliability and economy (both first cost and operation) of a station power system supplied from transformers rather than from house turbines or shaft generators.
2. In the unit system of plant arrangement, it is advantageous to connect station power transformers at generator voltage, so as to provide a natural cushion against transmission-system faults. However, this is not so necessary, if faults on the transmission system are cleared with modern relay and breaker speeds and the control system is properly co-ordinated.
3. The use of intermittent-running–automatic-starting constant-speed motors for certain applications and variable-speed couplings for others results in the use of line-

starting squirrel-cage induction motors for practically all drives, with important advantages in reliability, simplicity, flexibility, and convenience in operation.

4. Careful analysis of drive characteristics and comprehensive performance tests has resulted in the use of inexpensive control and switching equipment for the many noncritical auxiliaries, with more costly equipment limited to a few essential applications.

5. The problem of protecting motors and circuits in a central station differs from the typical industrial application, since in the former the proper co-ordination of motors with drive characteristics, maintenance on a program basis, and close surveillance by station operators of equipment and its performance eliminates many causes of motor failures. Accordingly, in central stations, schemes of protection should emphasize continuity of service.

Distribution systems, motors, and switchgear, for central-station auxiliaries were the subjects high-lighted in a paper by H. N. Muller, Jr. (M '43) of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. With reference to a network system for supplying power to auxiliaries, he indicated that the advantages of reliability, flexibility, and simplicity of this type may be obtained at less cost than a radial system of comparable reliability. The use of squirrel-cage motors with full-voltage starting wherever possible was recommended. The requirements of reliability in switchgear were held to be met best by metal-enclosed equipment.

Auxiliary power supply in the Southwark station of the Philadelphia (Pa.) Electric Company was described in a paper by J. H. Harlow (M '43). This station is now under construction, and will comprise a 150,000-kw 0.8-power-factor cross-compound hydrogen-cooled turbogenerator, two 850,000-pound-per-hour open-pass boilers, and the necessary complement of auxiliaries. A future second unit is contemplated. As a result of certain known factors and experiences, the plan adopted comprises an auxiliary turbogenerator for each main unit of sufficient capacity to drive the essential main-turbine and boiler auxiliaries. Each auxiliary unit will supply two 4,000-volt auxiliary bus sections. To each of these bus sections all of the auxiliaries for one boiler and about one half of the auxiliaries for the main unit will be connected. Station-service auxiliaries and lighting will be connected to two 4,000-volt station-service bus sections which will be supplied through transformers from the main station 13.2-kv bus. Provision will be made for connecting the station-service bus sections with the auxiliary-generator bus sections so that power will be available during outages of the auxiliary generator. These connections will not be closed under normal conditions.

The design of auxiliary power supply on the system of the Commonwealth Edison Company was presented in a paper by V. E. McCallum (M '38). He summarized five essentials for the main characteristics of the auxiliary power supply of a generating station, where auxiliaries are driven by motors, as follows:

1. A separate and independent auxiliary supply unit will be set up for approximately 100,000 kw of generating capacity.

2. The auxiliary power service units will be fed from the main station busses.

3. Each auxiliary power center is to be supplied by two lines operating in parallel, one line connected to the bus supported by the generating unit and one line for the reserve transformer from the bus on an opposite system supported by a transmission line.

4. All contactors, circuit breakers, relays, and control apparatus are to be installed in separate well-ventilated rooms.

5. For simplicity, it is recommended that two voltages be employed and the services to all motors be standard and have the same method of operation.

After the presentation of the prepared papers, 12 discussions were presented from the floor, the salient features of which follow:

1. Where space is at a premium the space requirement for switchgear may become a very important element, and the same would apply to space requirement for conduit. If electric distribution could be simplified along the lines of steam distribution by the elimination of multiple circuits, a considerable reduction in first cost could be effected.

2. Another method of cost reduction could be had by tying more than one motor on a single circuit breaker.

3. Where the choice lies among a house generator, shaft generator, or transformer for supply, the transformer offers the lowest cost. However, it is contended that the higher cost for the house generator is justified by its better reliability.

4. A suggestion was made that studies be undertaken to determine how much frequency can be reduced before loss of motors occurs.

5. One company reported trouble with fly-ash deposits on induced-draft fan motors.

6. With reference to space requirement it was pointed out that on one hydroelectric system in Canada, two 8,000-kw house turbogenerators occupy the same space as a 40,000-kw unit.

7. There appears to be no justification for providing low-voltage protection with time-delay relaying for motors operated at less than 2,300 volts.

8. It was suggested that more thought be given to the minimum size motor that can be justified for operation at 2,300 volts.

9. The merits of grounded and ungrounded systems should receive more study.

(*A. J. Krupy, chairman, AIEE committee on power generation*)

Vice-President J. F. Fairman (F '35) Consolidated Edison Company of New York, Inc., New York, Tomlinson Fort, Jr. (M '35) Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and Vice-President R. T. Henry (F '33) Buffalo, Niagara and Eastern Power Corporation, Buffalo, N. Y., find F. S. Brown (M '27) Duquesne Light Company, Pittsburgh, Pa., to be an attentive listener. Mr. Fairman was chairman of the winter technical meeting committee, and Mr. Brown presided at the session on electric machinery

Diverse Subjects on Power-Generation Program

At the session on power generation held January 22, four papers on nonrelated subjects were presented and were followed by 14 discussions. Brief summaries of each paper and the related discussions follow.

The paper, "Evaluation of Electric-Distribution Losses in Terms of Generating-Station-Capacity Investment," was presented by Mario Mortara, consulting engineer. His paper reduced to mathematical terms the procedure normally followed in evaluating distribution losses in terms of required investment of generating capacity. The paper was not intended to apply to high-voltage-transmission-line losses. The general consensus was that the paper is a valuable and interesting contribution to engineers concerned with the design of distribution systems, since it clearly sets forth the underlying principles for evaluating alternate schemes based on long-time trends. Some criticism was made of the title of the paper for not indicating that the paper deals with power losses as distinguished from energy losses. It was suggested that the evaluation should be made on the basis of average losses instead of peak-power losses, since the losses vary considerably during the peak period of the daily load cycle. Some discrepancies in the derivation of equations 12 and 13 of the paper were pointed out.

H. C. Marcroft (A '31) of the Pennsylvania Water and Power Company, Baltimore, Md., presented: "Use of Dielectric-Absorption Tests in Drying Out Large Generators," in which he described a method for utilizing the dielectric absorption of generator-winding insulation to indicate when full operating voltage may be applied with safety. The method, with some modifications, has been in use on several electric systems for about two

years with all-around satisfactory results. It was stated that, in view of the general agreement that the procedure described by Mr. Marcroft was an improvement in the technique previously employed, the paper should be of considerable value to those concerned with the problem of moisture removal from generator-winding insulation. Direct voltage of 500, 1,000, or 1,500 volts supplied from a storage battery, which it is claimed is preferable to available mechanical, chemical, or electric rectifiers, was used. On some systems, direct voltages up to 1,500 volts are employed.

The paper, "Frequency Changers—Characteristics, Applications, and Economics," was presented by S. B. Crary (M '37) and R. M. Easley of the General Electric Company, Schenectady, N. Y.

A paper of the AIEE—ASME Joint Committee on Turbogenerators, "Proposed Preferred Standards for Large 3,600-Rpm Three-Phase 60-Cycle Condensing Turbogenerators," was presented by M. S. Oldacre (M'42) of the Commonwealth Edison Company, Chicago, Ill., who was chairman of the group representing AIEE. The proposed preferred standards for the generator are based on replies to a questionnaire submitted to many operating companies, and they represent the majority viewpoint. It was emphasized that the proposed standards may not meet the requirements of all systems, and are not intended to preclude a modification of the standards when required. The primary justification for establishing preferred standards is the reduction in cost and time for delivery, and it is obvious that the purchaser of a nonstandard machine will lose these benefits.

The preferred standards have been submitted to the AIEE board of directors by the Standards committee with the recommendation of approval for a trial period of one year, which will allow ample time for consideration of any modifications which may be submitted during this period.

Suggestions submitted for consideration were:

1. Specification of pull-out torque.

2. Specification of maximum capability when the generator is operated without hydrogen cooling.

3. Too much emphasis has been placed on the inclusion of pilot exciters. Many systems operate units without pilot exciters, and the question arises whether pilot exciters should be specified as standard equipment.

4. A plea was made for the preparation of preferred standards for units rated under 10,000 kw to meet the requirements of designers of power supply for industrial users.

(*A. J. Krupy, chairman, AIEE committee on power generation.*)

Conference Plans to Resolve D-C Temperature-Data Conflict

A proposal for the revision of American Standard *C*50, presentation of data on the stray-load loss in d-c machines, and submission of a proposed testing code for carbon brushes comprised the agenda of the conference on temperature measurement of d-c machines, held January 23 during the winter technical meeting.

The proposal for the revision of Table I in the American Standard to cover short-time-rated machines and temperature measurement by the resistance method came from T. M. Linville (M '34) of the General Electric Company, Schenectady, N. Y. However, it was agreed, because of conflicting data on a suitable differential in temperature rise between the thermometer and resistance, that it would be desirable to interchange some motors and secure data on several motors in several laboratories. The motor size for these experiments should be 10 to 25 horsepower, and anyone desiring to participate in the experiments should communicate with W. R. Hough (M '41) of the Reliance Electric and Engineering Company, Cleveland, Ohio.

E. R. Summers (A '38) and L. H. Stauffer (M '43) of the General Electric Company, Schenectady, N. Y., presented a proposed testing code for carbon brushes and an account of their experience with such testing. Dimiter Ramadanoff (M '37) of the National Carbon Company, Cleveland, Ohio, outlined some of the difficulties encountered in this testing. The conferees decided that the proposed code be referred to the committee on electric machinery with the recommendation that a joint subcommittee of that committee and the committee on air transportation consider the proposal. (*W. R. Hough, chairman, AIEE d-c machinery subcommittee.*)

C. M. Dodd, Ames, Iowa, who is chairman of the promotion and development committee of the Institute of Ceramic Engineers, with A. J. Krupy (M '33) Commonwealth Edison Company, Chicago, Ill., chairman of the committee on power generation, who presided at several technical sessions

Conference on High-Frequency Dielectric Heating

The conference on high-frequency dielectric heating, presided over by J. J. Orr (A '30) of the committee on industrial power applications attracted a larger attendance than many technical sessions. The first paper presented, by C. J. Madsen (M '44) Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., reviewed the advancement and use of dielectric heating.

The second paper presented at the conference was by T. W. Scott, Jr., Armstrong Cork Company. He discussed the determination of the practical upper limit for frequencies for heating with the object of selecting frequency bands for use during the period of the next few years. By the establishment of such bands, co-ordination between the users and suppliers of equipment could be facilitated.

An experimental use of dielectric heating in the curing of sponge rubber was described by E. L. Bailey (F '43) of the Chrysler Corporation, Highland Park, Mich., who said the curing time had been reduced from as much as three hours to about three minutes. For this application, specially designed electrodes were used with glass molds to serve as restraining forms. Contrary to the usual practice of curing rubber in a mold, the temperature of the container is never higher than that of the charge.

Discussion followed the presentation of the three papers and was concerned largely with the problem of voltage measurement. P. L. Bellaschi (F '40) Westinghouse Electric and Manufacturing Company, Sharon, Pa., compared the present status to that which prevailed in 1934 on impulse voltage and current measurement. He advocated the expansion of AIEE Standard 4 by the extension of frequency limits.

At the end of the discussion period, a report of the Federal Communications Commission which covered frequencies for heating, medical, and scientific uses was read, with particular reference to its application in the field of high-frequency dielectric heating. It was indicated that the narrow frequency bands assigned for this use would require excellent frequency control and stability, which would lead to the use of crystal-controlled oscillators. A proposal was made by H. C. Gillespie of the RCA Victor Division of the Radio Corporation of America, that the power rating of equipment be expressed in Btu per hour in order that there may be a common ground for users and manufacturers.

Educational Program Planned at Conference on Statistical Methods

Plans for an educational program to include a series of articles in *Electrical Engineering* was one of the important outgrowths of the conference on statistical applications held during the AIEE 1945 winter meeting. The first article in the series is tentatively scheduled to appear in the April issue. The conference was sponsored by the joint committee for development of statistical applications in engineering and manufacturing. Purpose of the conference was to give information on the principles of statistical analysis as applied to quality control and to describe several applications with a view to arousing interest and promoting study of applications in the electrical field. W. P. Dobson (F '43), chairman of the joint committee, presided.

Four papers were presented dealing with: statistical tools for controlling quality; statistical methods applied to insulator development and manufacture; application of quality control to resistance welding; and the demerit schedules of Underwriters' Laboratories. These were followed by a comprehensive discussion.

Several speakers stressed the lack of knowledge among engineers of the technique of statistical applications and suggested that the subcommittee undertake an educational program. Several applications in war industries, in addition to those treated in the papers, were described. Information was furnished regarding intensive short courses available to Institute members. The discussion also covered the interest of the purchaser and his relation to the manufacturer, and the possible savings in inspection costs by the application of statistical methods.

In view of the interest of the Government

and industry in the expansion of standards in the consumer-goods field, it was suggested by several that the application of statistical methods of quality control would be an important factor in labeling and certification programs. Test procedures should be worked out and laboratory facilities provided for making tests. The value of the statistical viewpoint in relation to problems in economy was pointed out.

Those taking part in the discussion included: J. Manuele and Casper Goffman, Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.; P. L. Alger (F '30) General Electric Company, Schenectady, N. Y.; H. F. Dodge, Bell Telephone Laboratories, New York, N. Y.; M. M. Brandon (M '36) Underwriters' Laboratories, Inc., New York, N. Y.; A. I. Peterson (A '23) New York University, N. Y.; L. S. Hobson (M '39) and R. S. Inglis, General Electric Company, Philadelphia, Pa.; J. J. Taylor (A '37) Ohio Brass Company, Barberton, Ohio; C. B. Brown (A '37) Naval Ordnance Laboratory, Washington, D. C.; R. L. McCoy (M '43) Locke Insulator Corp., Baltimore, Md.; and Professor Grant. (*W. P. Dobson, committee chairman.*)

Army–Navy Group Co-operates in High-Frequency Conference

An all-day conference session on high-frequency cables under the sponsorship of the AIEE committee on communication with the co-operation of the Army–Navy Radio-Frequency Cable Co-ordinating Committee was held January 26. Lieutenant Commander John H. Neher (M '38) United States Naval Reserve, presided.

An outline by Commander Neher of the development of radio-frequency cables from the time of the United States's entry into the war until the present briefly introduced the general subject and explained the establishment of the Army–Navy Radio-Frequency Cable Co-ordinating Committee, its functions, and what it has accomplished.

The characteristics of polyethylene used as the dielectric in radio-frequency cables were discussed under the leadership of W. J. Clarke of the Bell Telephone Laboratories, Inc., New York, N. Y. The general characteristics of the material were presented by J. W. Shackelton of E. I. Dupont de Nemours Corporation; its use as cable insulation by A. E. Maibauer of the Bakelite Corporation; and its dielectric strength by Wm. A. Del Mar (F '20) of the Phelps-Dodge Copper Products Corporation, Yonkers, N. Y.

Mr. Clarke explained the difference between the various grades of the British product and that manufactured in the United States and compared the properties of several samples of polyethylene from different sources.

T. M. Odarenko (M '42) of the Federal Telephone and Radio Corporation, New York, N. Y. presented a discussion on radio-frequency cable manufacture.

The discussion on cable design, which was led by J. F. Wentz (M '42) of Bell Laboratories included a general statement by him of the design considerations involved; and remarks on power ratings and stability by M. C. Biskeborn (A '32) of the Bell Laboratories, a discussion on shielding characteristics of the cables by R. G. Fluharty of the Radiation Laboratory, and a consideration of losses in components by G. L. Ragen of the Radiation Laboratory.

Dixon Lewis (M'38) Aluminum Company of America, and F. W. Linder (A'41), Rural Electrification Administration St. Louis, Mo., author of a paper presented at the protective-devices session

E. E. Sheldon (M '43) of the General Electric Company, Bridgeport, Conn., presented a summary of the types of radio-frequency cables now included in the "Army–Navy Standard List of Cables and Specifications."

The final subject, cable testing, was introduced by J. M. Miller of the Naval Research Laboratory who discussed the standard electrical and mechanical tests required by the armed services. This was followed by discussions on electrical tests over a wide range in frequencies by C. C. Fleming of Bell Laboratories; measurements at relatively low frequencies, using a special method by C. Stewart, Jr., of the Aircraft Radio Laboratory; and measurements of corona initiation by Ensign D. DePackh, United States Naval Reserve, of the Naval Research Laboratory. (*Lieutenant Commander John H. Neher, chairman, Army–Navy Radio-Frequency Cable Co-ordinating Committee.*)

Aircraft Groups Active at Winter Meeting

Two technical sessions, a meeting of the air transportation committee, a meeting of the subcommittee for aircraft electric rotating machinery, and a conference on aircraft electricity gave aviation a leading place in the winter-meeting program.

The question of the handling of aircraft technical papers in the absence of national technical meetings during the present emergency occupied the attention of the air transportation committee meeting and the conference on aircraft electricity. Encouragement of local discussion groups and, if possible, preliminary presentation of would-be technical papers before local groups was recommended as a method of keeping up the supply of papers dealing with aircraft. The committee on air transportation will continue to formulate a procedure of soliciting, reviewing, and presenting papers.

The status of standards for aircraft electric systems was summarized at the air-transportation meeting by J. R. North, and is reported elsewhere in this issue (*p. 122*). The method of attacking the problem of evaluating types of electric systems for aircraft from the standpoint of alternating or direct current and the selection of voltages and frequencies was discussed.

At the conference on aircraft electricity W. A. Petrasek (A '36) of the American Airlines, Inc., New York, N. Y., emphasized the need for the utmost in reliability and serviceability of systems and equipment and pointed out that military and commercial requirements in this connection were not necessarily identical.

At the meeting of the subcommittee for aircraft electric rotating machinery, which is responsible for drafting test codes and Standards, it was agreed that further work on Standards must wait until the environmental standards to be issued by National Aeronautical Standards Council are available. The immediate efforts of the subcommittee will be devoted to a test code for d-c aircraft machines. Each member will review AIEE Standard 501, recommend additions necessary for adapting it to aircraft machinery, and advise on the material believed to be suitable without change.

Whether or not temperature is a suitable basis for rating an aircraft motor or generator also was discussed at the subcommittee meeting. Statistical methods of demonstrating equipment life are highly desirable, it was said, but should be flexible enough to be satisfactory for military equipment with an expected life of 500 hours and for commercial equipment which must be suitable for much longer life and which must be evaluated in terms of cost, pay load, maintenance, and replacement. W. F. Fell stated that the air lines would demand 2,000 to 3,000 hours' life. Other estimates went higher and lower. In general, however, it was believed that expected life would be short enough to make actual life tests practicable. F. B. Hornby declared that the air lines would be satisfied, if no maintenance were required between engine overhauls—probably 1,000-hour intervals for postwar airplanes. M. L. Schmidt (M '43) of the General Electric Company, Fort Wayne, Ind., mentioned experience with demands for motors to operate for the life of the airplane without attention.

On the whole it was agreed that with the rapid development of new materials, if temperature is to be the basis of rating of equipment, some entirely new values must be set to match environment, materials, and life requirements.

The explanatory introduction accompanying the table of recommended voltages adopted by the air transportation committee at the winter meeting for one year's trial use was reviewed by the subcommittee. No values listed in the table were changed, but provision for one-second tests and clarification of field-test values were added to match American Standard C50. (*D. R. Shoults, chairman, AIEE committee on air transportation.*)

E. L. Bailey (F'43) Chrysler Corporation, Highland Park, Mich., who presented a paper at the session on industrial power applications

Sections Committee Has Lengthy Agenda

The transfer of Mexico from District 3 to District 7 as a step toward establishing another District was the subject for a unanimously adopted motion at the meeting of the Sections committee held in New York on January 24. Another transfer approved by the committee was that of Allen County, Ohio, from the Toledo to the Dayton Section.

After a discussion of the effect of the cancellation of national technical meetings upon the clinic method of treatment of Section operation and management problems, it was decided that the clinics should be continued on a District or area basis. Satisfaction with the clinic plan was found among delegates to the St. Louis meetings, who were polled by means of a questionnaire. A demand for less formal meetings at which more time would be devoted to discussion among the delegates also exists, and this has been considered in planning future clinics. It also is planned to conduct clinics falling under the travel ban by mail.

The growth and interest in technical groups and subsections is reflected in the committee's report that the supply of folders on both types of organization has been exhausted. Four subsections have been organized within the year bringing the total to 13. As an example of the effect of subsections on AIEE membership in general, M. S. Coover (F' 42) vice-president for District 5 cited the Arrowhead Subsection formed where originally only two AIEE members resided. Attendances of 90, 80, and 78, respectively, were recorded for the first three meetings. Twelve applications for membership were received almost immediately, and more are on the way.

Additions to the technical groups during the year number 15, and others are reported under consideration.

A plea for more newsworthy items about Section activities and for submission of Section papers which might be suitable for publication in *Electrical Engineering* was made by H. H. Race (F '39) chairman of the publication committee.

R. M. Pfalzgraff (M '41) vice-chairman of the Sections committee outlined the more liberal appropriations now allowed to Sections and reviewed the ways in which Sections could take advantage of these increased appropriations.

Problems of Section operation and management, Section publicity, the simplified report of Section chairman, revision of the pamphlet on Section activities, local section write-up on duties of Section officers, the report of the subcommittee on civic responsibilities of engineers, the organization of local engineering councils, increasing the number of Section operating committees, distributing member activity information, and the status of the third man permitted an allowance to attend one District meeting a year, also were discussed at the meeting. G. W. Bower (M '40) chairman of the Sections committee presided. (*A. C. Muir, secretary, AIEE Sections committee.*)

MEMBERSHIP ACTIVITY

The Membership Committee wishes to thank the members of the Institute for the splendid response to the request for names of persons thought to be qualified for membership in the Institute. Again we say the interest of the individual member in this regard is important and helpful.

Chairman, Membership Committee

Committees and Subcommittees Meet During Winter-Meeting Week

Following their usual practice, many of the AIEE committees and subcommittees held meetings in New York, N. Y., during the 1945 winter technical meeting. Actions of interest to the membership taken at some of these meetings are outlined in the following paragraphs which have been prepared from reports submitted by the committee chairmen. Other committee meetings are reported separately.

MEMBERSHIP

The membership committee, which met Thursday afternoon, January 25, reports that current membership applications are being received at a favorable rate equal to the same period for 1943–44. The number of transfers to higher grades of membership is almost equal to that obtained for the corresponding period for last year. The only unfavorable aspect of the membership picture is the decline in the number of Student members from whose ranks new members of Associate grade can be recruited. It is expected that the downward trend in the number of Student members, which is now 1,300 below last year, will continue for a time, since it is a direct reflection of the impact of the war on the colleges.

The committee also expressed appreciation for the response of AIEE members to its request for the names of persons thought to be qualified for membership. L. F. Howard (M '25) chairman of the committee, presided.

LAND TRANSPORTATION

It was announced at the meeeting of the land transportation committee Thursday morning, January 25, that the committee had been successful in producing several papers in its field which are now available. The subjects covered are: measurement of railway-motor temperatures, dynamic braking on traction motors; new developments in end-to-end, train-to-train, and train-to-wayside communication; the carbon-shoe insert for current collection from overhead contact systems; and the engineering problems involved in the maintenance of motor armatures. Other papers in preparation, according to the committee, deal with ventilating processes on electrically driven vehicles, air-conditioning for city transit, railway electrification as a potential market for power, Diesel-electric locomotive costs. The suggestion by Llewellyn Evans (F '41), chief consulting electrical engineer for the Tennessee Valley Authority, Washington, D. C., that the power from such projects might be used for low-cost electric-traction projects in the vicinity of the power source is being given further consideration by Mr. Evans at the request of the committee. H. C. Griffith (M '35) chairman of the committee, presided.

INSTRUMENT TRANSFORMER SUBCOMMITTEE

At the meeting of the instrument transformer subcommittee of the instruments and measurements committee on Thursday, January 25, a proposed revision of the American Standard *C57* was reviewed for the AIEE and substantially approved with a few minor changes. The proposed revision was prepared by a joint working committee of the relay subcommittee of the committee on protective devices and the instrument transformer committee of the American Standards Association. Paul MacGahan (F '42) chairman of the subcommittee, presided.

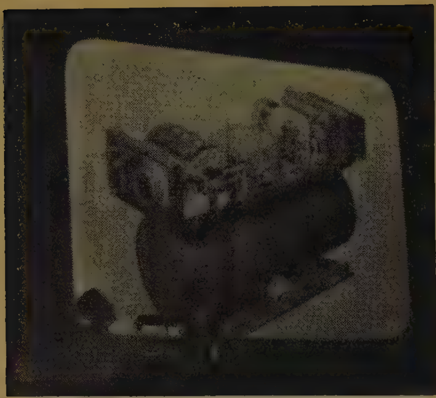
SUBCOMMITTEE ON STATIONARY CONTACTS

A survey sheet prepared by the subcommittee on conduction in stationary contact surfaces is now ready for distribution, it was revealed at the meeting of the subcommittee on Thursday, January 25. The subcommittee wishes to obtain data on causes of failure from users of contacts. The subcommittee expects the survey to aid in determining the basic principles required for future standardization of electrical contacts.

It was decided to revise and expand its paper, "Temperature Limits and Abstracts of Present Standards and Practicesfor Stationary Contact Surfaces," presented at the 1945 winter technical meeting. W. P. Dobson (F '43) chairman of the subcommittee, presided.

INSULATION RESISTANCE SUBCOMMITTEE

Investigating the physical and dielectric qualities of various silicone resins is the newest assignment of the subcommittee on insulation resistance which met Thursday, January 25, A. M. de Bellis (M '33) chairman of the subcommittee, revealed. The ultimate object of the investigation will be preparation



L. L. Ray (A '44) General Electric Company, Fort Wayne, Ind., illustrates a paper at the session on aircraft electric apparatus and utilization

of recommendations for committee adoption which will set definite operating limits for these new insulating materials. Though it generally was agreed that immediate standards for silicones would be premature, it also was pointed out that considerable time would be required to collect information, and it was agreed that a working group should be appointed.

The fourth draft of "Recommended Practice for Insulation Resistance Testing of Rotating Machinery" was reviewed at the meeting and was approved with slight changes. It is expected that the recommended practices will be available for action by the electric machinery committee and for distribution within the next few months.

MERCURY-ARC RECTIFIER SUBCOMMITTEE

Meeting twice on January 22 and again on January 24 during the winter technical meeting, the mercury-arc rectifier subcommittee accepted three of the five sections which will comprise the Standards on mercury-arc rectifiers to be presented by the subcommittee to the American Standards Association within the next few months. In addition the subcommittee voted to sponsor a report on "Inductive Co-ordination of Rectifier Equipment," and a working group was appointed to prepare such a report. C. H. Willis (F '42) chairman of the subcommittee, presided.

SUBCOMMITTEE ON FAULT-CURRENT-LIMITING DEVICES

Some points of disagreement arising from the revision which AIEE Standard 32 is undergoing were smoothed out at a meeting of the subcommittee on fault-current-limiting devices held January 22. With only a few items remaining for its attention, the subcommittee expects that the revised Standard will be ready for balloting about July 1.

A questionnaire on "Present-Day Grounding Practices" is being prepared by the subcommittee as the basis of a report which will modernize and replace the reports of 1923 and 1931 on grounding practices. This project, according to the subcommittee, is still in its early stages. F. R. Longley (M '42) chairman of the subcommittee presided.

RESEARCH

Anticipating renewed research activity among colleges and universities at the close of the war, the research committee at its meeting on January 24 instituted plans to bring its lists of worth-while research projects abreast of the times. Such lists were distributed among educators several years ago as guides for graduate and undergraduate research in the field of electrical engineering. The committee will welcome any suggestions for such projects from Institute members. W. A. Lewis (M '39) chairman of the committee, presided at its meeting.

Drugs in Electric-Shock Treatment Topic at Safety Meeting

The paper, "The Use of Drugs in Resuscitation From Electric Shock," which was read by W. R. Smith (F '30) chairman of the AIEE safety committee, in the absence of the author, Cecil K. Drinker, professor of physiology, Harvard School of Public Health, Cambridge, Mass., keynoted the discussion at the well-attended joint committee meeting and conference held January 23.

It was emphasized that the administering of any injections deemed desirable by an attending physician as a stimulant, sedative, or pain killer, obviously is a matter of medical decision with which the discussion was not concerned. The discussion and paper considered drugs as an important aspect of first aid in electric-shock cases from the standpoint of their value in aiding resuscitation. Experience indicates that many doctors are too prone to resort to injections as a means of inducing natural breathing, it was brought out.

Doctor Drinker's paper considered the possible value of available substances and concluded that there is no known drug that has been shown to be effective in restoring breathing to normal. Furthermore, Doctor Drinker stated that nothing can be as beneficial as adequate lung ventilation by manual artificial respiration, and he assigned paramount importance to reliance on the latter method.

Discussion also dwelt upon the need for more widespread dissemination of information on approved manual techniques of artificial respiration to the members of the medical profession by competent medical authorities. Case histories continue to show that, in spite of the acceptance of appropriate manual techniques and the universal endorsement of the prone-pressure method by the medical profession, especially those members eminent in the field of physiology, there are still too many instances in which the importance and significance of such procedure is not recognized by doctors ministering in some way to electric-shock cases. Of equal importance with an understanding of the life-saving possibilities of manual artificial respiration as a first-aid measure is the appreciation of the critical importance of promptness of application in the electric-shock case. This has been stressed in all authoritative writings on the subject, but a more literal acceptance of its truth by all doctors, it is believed, would lead to a more general understanding of the need for saving every possible second of time. The committee will endeavor to promote realization of this fact and will seek the counsel of members of the medical profession in determining how best to do it.

The development of new and novel electric equipment, as electric fences, insect screens, and traps, has demonstrated the need for additional information on the maximum currents that human beings reasonably might be expected to withstand without fatal results, according to Mr. Smith. In this connection C. F. Dalziel (M '39), associate professor of electrical engineering, University of California, Berkeley, summarized the results of the research work on let-go currents carried on under his direction. Professor Dalziel's investigations appeared in AIEE *Transactions* as three papers: "Electric Shock" (written in conjunction with J. B. Lagen and J. L. Thurston) volume 60, pages 1073–8, "Effect of Wave Form on Let-Go Currents," pages 739–44, and "Effects of Frequency on Let-Go Currents," pages 745–50 of volume 62, December section. Discussion by H. B. Williams (M '41) of Columbia University, New York, N. Y., and S. P. Ferris (F' 34) of Bell Laboratories disclosed a need for more extensive data than those presented in their paper prepared jointly with B. C. King and P. W. Spence (M '34) of Bell Laboratories ("Effect of Electric Shock on the Heart," *Electrical Engineering*, volume 55, May 1936, pages 498–515). Chairman Smith promised consideration would be given to ways and means by which such research might be undertaken.

From the discussion of the subject of grounding of circuits with voltages in excess of 150 volts to ground, the opinion emerged that there undoubtedly would be some increase in the hazard to personnel, if circuits above this voltage (in the low-voltage class up to 550 volts) were grounded. Present code requirements, under which the grounding of circuits operating at voltages up to 300 volts to ground is merely recommended, and those in the class above 300 volts are left for optional decision depending upon conditions, are considered best.

In his report to the committee Mr. Smith directed attention to the column, "Safety," in the January 1944 issue of *Electrical Engineering* which inaugurated a feature to be continued as a means for the dissemination of information on matters of interest in the fields of electrical safety and allied subjects. He announced that Albrecht Naeter (M '30) Oklahoma Agricultural and Mechanical College, Stillwater, had prepared a communication to be sent to Student Branch counselors and chairmen which would be forwarded in the near future. Revision of the "Bibliography on Electrical Safety" is contemplated and will be carried forward as promptly as conditions permit. It was also announced that the proposed conference on static electricity would be held at an appropriate future time. (*W. R. Smith, chairman, AIEE committee on safety.*)

Variety of Types Discussed at Circuit-Breaker Session

At the technical session on circuit breakers held January 23 and presided over by H. E. Strang (M '39) four technical papers were presented.

The development of 3,500,000-kva three-cycle circuit breakers of the conventional tank-type oil-circuit-breaker configuration and a new compressed-air breaker was outlined in two papers by H. L. Byrd and E. B. Rietz (A '42) (A High-Capacity High-Voltage Three-Cycle Oil Circuit Breaker) and by B. S. Beall, III (A '41) and H. L. Byrd (A Three-Cycle 3,500-Megavolt-Ampere Air Blast Circuit Breaker for 138,000-Volt Service). Supporting data were presented, com

C. R. Hanna (M '39) chats with Past Director L. W. Chubb (F '21); both are with Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

paring these with previous designs and covering factory tests of both interrupting and reclosing performance.

A companion paper by Philip Sporn (F '30) and H. P. St. Clair (M '29) (Field Tests and Performance of Heavy-Duty High-Speed 138-Kv Circuit Breakers—Oil and Air-Blast) covered in considerable detail the results of extensive field tests on both of these breakers on the system of the Ohio Power Company. Short-circuit duty was available for these tests in wide range of steps up to 3,500,000 kva, which is the full rating of both breakers. This is the first time that short-circuit duty of this magnitude has been available for such field proof testing, which was agreed generally both by the authors and by those discussing the papers to be a highly desirable check on factory test procedure.

The fourth paper, "The Next Step in Interrupting Capacity—5,000,000 Kva," was by A. W. Hill (M '41) and W. M. Leeds (M '38) and presented data to support the selection of 5,000,000 kva as the next interrupting step for high-voltage circuit breakers. It is recognized that factory test facilities cannot be made available for tests at this duty, and a number of equivalent test procedures at lower amounts of power were discussed and their merits and limitations outlined. The results of tests of a new line of high-voltage circuit breakers under several of these methods led to the conclusion that high-voltage circuit breakers rated 5,000,000 kva could be made available, when the industry requires such a rating. (*H. E. Strang, chairman, AIEE committee on protective devices.*)

Annual Index for 1944 Is Available on Request

Contrary to the practice of recent years, the 1944 index to *Electrical Engineering* and AIEE *Transactions* will be issued in limited edition, available upon written request. For the past several years, the annual index has been mailed with *Electrical Engineering* as Section 2 of an early issue of the succeeding year. The decision to publish the index in limited edition and distribute it separately represents a further step in the conservation of our restricted supply of paper.

As announced in the February issue (*page 75*) the 1944 index has been delayed because of the delay in publishing the flood of 1944 technical papers and discussions. With the completion of that material, the index also has been completed and is now ready for distribution.

Copies of the index are being mailed without request to all members of all AIEE technical committees. In addition, copies are being sent to all subscribers to *Electrical Engineering* and to the "Supplement to Electrical Engineering—Transactions Section," because many subscribers retain or bind their copies for reference purposes. Others may obtain a copy without charge by writing to the AIEE order department, 33 West 39th Street, New York 18, N. Y.

STANDARDS . . .

Preliminary Standard for Aircraft D-C Apparatus

In view of the general recognition of the need for preferred voltage ratings for aircraft d-c electric apparatus which will be acceptable to manufacturers and users as a basis for voltage standards for aircraft systems and equipment a "Preliminary Standard for Aircraft D-C Apparatus Voltage Ratings" was recommended for one year's trial use by the air transportation committee on January 24. J. D. Miner, Jr. (M '42) of the Westinghouse Electric and Manufacturing Company, Lima, Ohio, was chairman of the subcommittee preparing the Standard.

The committee believes that many difficulties and much confusion will be eliminated by adopting suitable standard voltage ratings for all aircraft electric equipment. These standard voltages then should be made a part of specifications, and name plates should be marked accordingly. Apparatus should be designed for satisfactory operation over the voltage ranges given in the table but without the same performance guarantee as that for rated voltage. Performance data and acceptance tests should be on the basis of standard voltages. The committee recognizes the fact that special applications may require operation over wider voltage ranges than those shown.

Standardization of voltage ratings for aircraft electric accessories is especially difficult because of the close margins for application of aircraft equipment. The great majority of systems in use today are designated as 24-volt systems, since they employ 12-cell lead-plate storage batteries in parallel with the system. This designation has been established thoroughly by a long period of usage and will not be changed, despite the fact that, ordinarily, no part of the system operates at 24 volts. A 24-volt motor, if actually designed and tested for operation at 24 volts, may be considerably overloaded when operated from a system maintained at a voltage high enough to keep a 24-volt battery reasonably well charged.

Although the battery represents only a small portion of the available system capacity its limitations determine the voltages which must be used, and voltage ratings must be set accordingly. System voltage must be high enough to maintain the battery in a charged condition but not high enough to cause excessive battery heating. Twenty-four-volt systems usually are operated at between 27 and 28.5 volts at the point of regulation. Voltage is adjusted by setting the generator regulators, and the particular value chosen is at least partially dependent on the condition of the batteries. Generators must be capable of 30-volt output over the specified speed range to allow for voltage drops totaling $1^1/_2$ volts minimum (including the voltage drop in any paralleling resistors used) between each generator and its regulated point.

To obtain minimum weight, aircraft-system wiring is deliberately loaded heavily, and allowance must be made for voltage drop between the regulated point and the electric accessories. Best weight economy dictates the use of higher cable ratings for intermittent loads than for continuous loads. Rated voltage has been selected as 27 volts for continuous-duty devices and as 26 volts for intermittent-duty devices.

Accessories such as engine-starter motors must be capable of operation when the battery is the sole source of power. They also must operate after one or more generators have been paralleled with the battery, and in most cases they must be suitable for operation from 30-volt starter trucks.

Dielectric-test voltages for used or repaired equipment are not included in the table because sufficient information upon which to base a standard is not available. Dielectric tests should not be made unless the machine is clean and dry, and, even after thorough cleaning and drying, a used machine cannot be expected to withstand more than a fraction of the original factory test voltage. Testing used equipment at 40 to 50 per cent of the test voltage for new machines is rather common practice. Several Army technical orders recommend a 220-volt test for 12-

Preliminary Standard for Aircraft D-C-Apparatus Voltage Ratings†

This Standard applies to all types of aircraft d-c electric apparatus.

Nominal system designation	12	24	**120
Generators			
Rated voltages	15	30	125
Voltage adjustment range (per cent)	+0 to −15	+0 to −15	+0 to −15
*Continuous-duty devices			
Rated voltages	13	27	115
Voltage range (per cent)	±10	±10	****±10
*Intermittent-duty devices			
Rated voltages	12.5	26	***115
Voltage range (per cent)	±10	±10	****±10
Battery-operated devices			
Rated voltages	11.5	23	
Voltage range (per cent)	±25	±25	
Dielectric tests (Rms volts for one minute at 60 cycles, or 120 per cent of value shown for one second)			
Factory test volts	500	500	1,250
Field test *before* use (Clean and dry only—75 per cent)	375	375	950

Apparatus is to function satisfactorily over the voltage ranges given, but with performance not necessarily in accordance with guarantees at rated voltage.

† Recommended for one year's trial use by the AIEE air transportation committee January 24, 1945.

* For operation from a voltage-regulated system. If operation is required from battery alone, use voltage values for battery-operated devices.

** No battery is contemplated for this system, and for this reason, the nominal system designation and the system voltage are identical.

*** It is assumed that most 115-volt wiring will be applied on the basis of thermal rating, and provision for higher-voltage regulation on intermittent loads has not been made.

**** +10 per cent provides for some error in setting voltage regulators on a system that does not have the stabilizing influence of a battery.

and 24-volt generators, or 44 per cent of the original test voltage.

These matters have all been studied carefully by a subcommittee of the AIEE air transportation committee, and the tabulation gives recommended standard voltages and voltage ranges for d-c aircraft equipment.

AIEE Aeronautical Standard Work Progresses

Four subcommittees of the air transportation committee with specific assignments and definite membership have started work on their respective standardization problems, since the AIEE announced its program of co-operation with other interested organizations in October 1944 (*EE, Nov '44, p 412*), according to a report presented by J. R. North (F '41) to the air transportation committee meeting held during the AIEE winter technical meeting.

The subcommittees and the scope of each listed by Mr. North, who is liaison representative between AIEE and the Society of Automotive Engineers, the National Aeronautical Standards Committee, the National Electrical Manufacturers Association, the Army Air Forces, and the Navy which are the other interested groups, follow.

AIRCRAFT ELECTRIC SYSTEMS

Preparation of an informative report on "Fundamental Characteristics of Aircraft Electric Systems," has been undertaken by this subcommittee of which R. H. Kaufmann (M '41) of the General Electric Company, Schenectady, N. Y., is chairman.

The report will present the basic considerations involved in securing the most effective aircraft electric application technique. It will cover:

(*a*). An explanation of fundamental electrical problems.

(*b*). Characteristic data for finding the abilities and limitations of devices and apparatus which comprise aircraft electric systems.

(*c*). Systematic procedures for analysis or computation of aircraft-electric-system performance.

(*d*). General application practices.

The range of this work is indicated by the subject topics in the report, which will include:

1. General considerations.
2. Power and utilization equipment.
3. Control and protective equipment.
4. System considerations.
5. Definitions.
6. Working standards.
7. Electric-system design procedures.
8. Methods of computing and evaluating.

Various authorities throughout the industry, including users, designers, and manufacturers, will be requested to contribute material based on their particular knowledge and experience. The report is not intended to be in any way mandatory or restrictive, and all contributions will be appreciated.

AIRCRAFT ELECTRIC CONTROL AND PROTECTIVE DEVICES SUBCOMMITTEE

This subcommittee under the chairmanship of R. A. Millermaster (M '34) of Cutler-Hammer, Inc., Milwaukee, Wis., will prepare electrical Standards and test codes covering aircraft control and protective devices to aid in their rating, testing, and application or evaluation for aircraft service.

One of the most important problems being studied by this group is circuit-breaker characteristics, particularly their performance in adequately protecting cables.

AIRCRAFT WIRE AND CABLE SUBCOMMITTEE

Preparation of electrical Standards and test codes covering the rating, testing, and application of aircraft wires and cables is being carried on by this subcommittee of which W. S. Hay is chairman.

AIRCRAFT ELECTRIC ROTATING MACHINERY SUBCOMMITTEE

The setting up of electrical Standards, test codes, and definitions for aircraft electric rotating machinery has been assigned to the subcommittee. Immediate attention is being given to the formulation of a suitable test code for aircraft d-c machines, and a report on proposed standard voltages for aircraft d-c equipment has been issued (*see p. 121*). J. D. Miner, Jr. (M '42) of the Westinghouse Electric and Manufacturing Company, Lima, Ohio, is chairman of the subcommittee Group.

SECTION • • • • •

Quiet Trolley Described Before Michigan Section

A description of the evolution and performance of a "noiseless" streetcar was the feature of a talk on modern developments in city transit equipment which was presented before a recent meeting of the AIEE Michigan Section by S. B. Cooper, transportation application engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

The streetcar discussed, known as the "PCC" street car because it was designed by the Presidents Conference Committee set up by the larger transit companies to study metropolitan traffic services, insures quieter operation through the use of rubber truck springs and rubber-packed wheels, the absence of movable parts that rattle, and three kinds of brakes that operate without jolt or causing sway. Additional advantages over the old streetcars include speed comparable with that of an automobile, a built-in ventilating system, glare-free lighting, and soft, roomy seats.

Because of the general interest of the subject, members of the Detroit City Council and of highway and city planning commissions, as well as the public, were invited to attend the meeting.

Iowa Section Meets With Collins Radio Association

Members of the AIEE Iowa Section were entertained by the Collins Radio Company's technical association at a dinner meeting in Cedar Rapids, Iowa, February 6.

A discussion and comparison of present train control systems with a new radio train control system were given by E. A. Dahl, electronics engineer, and A. E. Ganzert, electrical engineer, of the Rock Island Railroad. Included in the talks was a description of the experiments conducted by the railroad on radio systems, both frequency modulation and amplitude modulation, from 28 to 2,600 megacycles. The talks were elucidated with slides. Afternoon trips to the Collins Company's main plant and to the generating station of the Iowa Electric Light and Power Company preceded the dinner.

PERSONAL • • • •

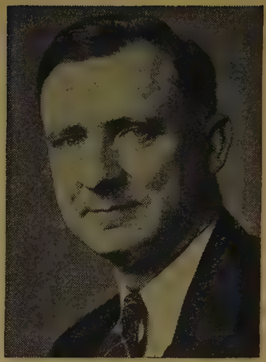
Soren Hanson Mortensen (A '09, M '12, F '20) chief electrical engineer, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been awarded the AIEE Lamme Medal for 1944, "for his pioneer work in the development of self-starting synchronous motors and for his contributions to the development of large hydraulic and steam-turbine-driven generators." Mr. Mortensen, who was born in Eskelund, Denmark, November 4, 1879, was graduated from the Polytechnicum of Mittweida, Germany, in 1902 with the degrees of electrical and mechanical engineer. Previously, from 1896 to 1898, he had gained experience as apprentice in various Danish firms and attended technical schools in Thisted and Aarhus and had served as a second lieutenant in the Danish Army. Leaving Denmark for the United States, he was employed from 1903 to 1905 as draftsman and mechanical engineer by the Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa. In 1905 he joined the Bullock works (then the Bullock Electric Company) of the Allis-Chalmers Company, Cincinnati, Ohio, as draftsman and designer of d-c motors and turbogenerators and in 1908 was transferred to Milwaukee. In the latter year also he was naturalized in the United States. After shifting his work to a-c turbogenerators in 1909, he was made designing electrical engineer in charge of synchronous motors and generators in 1911. He was named engineer in charge of the company's a-c design in 1932 and chief electrical engineer in 1942. Mr. Mortensen holds a number of patents for specific design features of large salient-pole machines and large air- and hydrogen-cooled turbogenerators. In 1944 he received the honorary degree of doctor of engineering from the Illinois Institute of Technology. He has been a frequent contributor to electrical periodicals and is the author of a textbook, "Electrical Machine

S. H. Mortensen

W. E. Wickenden

F. F. Evenson

F. L. Lawton



H. B. Wolf

Design," and of the section on "A-C Generators and Motors" of the McGraw-Hill "Standard Handbook for Electrical Engineers." An active AIEE member, Mr. Mortensen currently is serving as a director of the Institute and has served on many AIEE committees, including those on electrical machinery, application to iron and steel products, Standards, publication, and the Edison Medal. He has served as secretary and chairman of the Milwaukee Section. Since 1937 he has been Allis-Chalmers representative on the electric-equipment committee of the Edison Electric Institute. He is a member of National Electrical Manufacturers Association committees and represents that body on several committees of the American Standards Association.

W. E. Wickenden Nominated for AIEE President

William Elgin Wickenden (A '07, M '13, F '39) president, Case School of Applied Science, Cleveland, Ohio, has been nominated to serve as president of the AIEE for the 1945–46 term. Doctor Wickenden, who was born on December 24, 1882, in Toledo, Ohio, was graduated from Denison University with a bachelor-of-science degree in 1904. In addition, he has been awarded honorary degrees of doctor of engineering by Lafayette College in 1926, Worcester Polytechnic Institute in 1927, the Case School of Applied Science in 1929, and the Rose Polytechnic Institute in 1932. He also received the degrees of doctor of science from Denison University in 1928 and Bucknell University in 1930, that of doctor of laws from Oberlin College in 1930, and that of doctor of humane letters from Otterbein College in 1933. Doctor Wickenden's professional career began in 1904 with an appointment as an instructor in applied electricity at Mechanics Institute, Rochester, N. Y. In 1905 he joined the faculty of the University of Wisconsin, Madison, as assistant in physics, becoming instructor in electrical engineering the following year. He was named assistant professor of electrical engineering in 1909 and in 1914 associate professor at the Massachusetts Institute of Technology, Cambridge. In 1918 he joined the Western Electric Company, New York, N. Y., as personnel manager and in 1921 he became assistant vice-president, American Telephone and Telegraph Company, New York. From 1923 until 1929, when Doctor Wickenden became president of the Case School, he was director of investigation of engineering education, sponsored jointly by the Society for the Promotion of Engineering Education and the Carnegie Corporation. In addition to his AIEE vice-presidency in 1943–44, his AIEE activities include service on the committees on education, 1918–19 and 1922–23, technical program for 1922–24 and 1937–38, Student Branches for 1928–29, Edison Medal for 1942–43, and Cleveland Section chairmanship in 1936. Doctor Wickenden has served as chairman of the Ohio Highway Planning Board, as vice-chairman of the American Council on Education, and as vice-president of the American Association for the Advancement of Science. He is a fellow of the AAAS and a member of the SPEE, the American Society of Mechanical Engineers, the American Academy of Political and Social Science, and the Cleveland Engineering Society. He was awarded the AIEE Lamme Medal in 1935.

Evenson, Lawton, Wolf, Fields, and Robertson Are Nominated for Vice-Presidents

Franklin Fenelon Evenson (A '21, M '29) consulting engineer, San Diego, Calif., and vice-president and general manager, American Products Inc., San Diego, has been nominated as AIEE vice-president for the Pacific District (8). Born in Iron River, Wis., on May 14, 1897, Mr. Evenson received a bachelor-of-arts degree in mechanical engineering from Stanford University in 1920 and an electrical-engineering degree in 1921. From 1921 until 1924 he was associated with the City of Los Angeles (Calif.) Bureau of Power and Light as junior electrical engineer. He was with the Benson Lumber Company, San Diego, Calif., in 1924 in lumber sales and manufacture and in 1928 he entered the special construction department of the San Diego Gas and Electric Company. In 1929 Mr. Evenson engaged in consulting engineering. In this capacity he was chief electrical engineer in charge of the electrical department of the California Pacific International Exposition, 1934–35, and, in 1940, he designed and supervised construction of the transmission and distribution system of the Mountain Empire Electric Cooperative, Inc., Campo, Calif. Mr. Evenson assisted in the preliminary organization of the AIEE San Diego Section (1938), served as chairman of the Section (1938–40) and served as a member of the national nominating committee in 1943. He is a member of the Electric Club of San Diego and the Engineers Club of San Diego, and has served as vice-chairman of the engineering committee of the Chamber of Commerce.

Frederick Lewis Lawton (A '25, M '36) assistant chief engineer, Aluminum Company of Canada, Ltd., Montreal, Quebec, has been nominated for AIEE vice-president for the Canada District (10). Born in London, England, December 14, 1900, Mr. Lawton was graduated from the University of Toronto in 1923 with the degree of bachelor of applied science in electrical engineering. After graduation, he joined the General Electric Company, Schenectady, N. Y., first on test and later in the general engineering laboratory and the engineering general department on transmission-system stability investigations. During 1926–27 he was with the Quebec Development Company, Ltd., at Isle Maligne, as assistant to the electrical engineer engaged in the construction of power-transmission facilities in the Saguenay district. In 1927 he joined the Duke-Price Power Company, Ltd., later the Saguenay Power Company, Ltd., as assistant to the superintendent of operation. He became electrical engineer in 1930 and chief engineer in 1937. He was appointed assistant chief engineer of the Aluminum Company of Canada, Ltd., in 1941. Mr. Lawton is chairman of the AIEE Montreal Section. He is a member of the Engineering Institute of Canada, the Canadian Electrical Association, and the Corporation of Professional Engineers of Quebec. He is also the author of a number of papers on diversified engineering subjects.

Herman B. Wolf (A '26, M '37, F '45), superintendent of maintenance, Duke Power Company, Charlotte, N. C., has been nominated as AIEE vice-president for the Southern District (4). Born in Dallas, N. C., September 10, 1896, and graduated from the Baltimore Polytechnic Institute in 1915, he was employed in 1916 by the Southern Power Company, which later became the Duke Power Company. He served in system maintenance and construction as repairman, foreman, and maintenance engineer, and, in 1941, was appointed superintendent of maintenance. Mr. Wolf de-

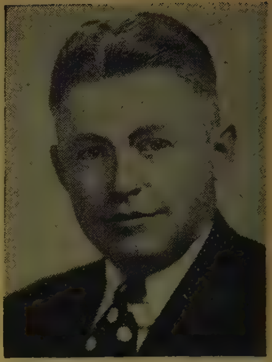
veloped testing methods and equipment for use in maintenance of generating, transmission, and distribution apparatus. He also developed high-voltage protective equipment, mobile emergency equipment, and equipment for fire protection. He has contributed a number of technical papers to the Institute and served as chairman of the North Carolina Section in 1941. He has also served as a director of the North Carolina Society of Engineers, president of the Charlotte Engineers Club, and trustee of Lenoir-Rhyne College.

Ernest S. Fields (A '20, M '26, F '29) vice-president, the Cincinnati (Ohio) Gas and Electric Company, has been nominated for AIEE vice-president for the Middle Eastern District (2). Mr. Fields was born in Bracken County, Ky., on August 27, 1897. He entered the employ of the Union Gas and Electric Company, Cincinnati, in 1918, as maintenance electrician and operator; in 1920 became chief electrician; and in 1922 was appointed assistant engineer. In 1929, after two years with the Columbia Engineering and Management Corporation, Cincinnati, he returned to the Union Gas and Electric Company as manager. Mr. Fields joined the staff of the Cincinnati Gas and Electric Company as manager in 1936 and was made vice-president in 1943. He was a charter member of the Cincinnati Section when it was organized in 1920, secretary of the Section in 1924 and 1925, and chairman in 1931. He has served on the AIEE national nominating and membership committees. Mr. Fields is, at present, chairman of the general engineering division of the Edison Electric Institute.

Lawrence Marshall Robertson (A '27, M '38) in charge of the transmission and station engineering department, Public Service Company of Colorado, Denver, has been nominated for AIEE vice-president for for the North Central District (6). He was born in Denver on January 20, 1900, and was graduated from the University of Colorado in 1922 with a degree of bachelor of science in electrical engineering. He also holds degrees of electrical engineer and master of science from the University of Colorado and a bachelor-of-laws degree from the Westminster Law School. He has been with the Public Service Company of Colorado since 1922 and has been in charge of the transmission and station engineering department since 1925. From 1935 to 1940 Mr. Robertson was chairman of the engineering division, Rocky Mountain Electrical League. He was vice-chairman of the AIEE Denver Section for 1940–41, chairman for 1941–42, and, at present, is serving on the AIEE committees on power transmission and distribution and electrical machinery. Mr. Robertson is a member of the Colorado Society of Engineers and the Colorado Engineering Council.

W. C. Smith

W. I. Slichter



L. M. Robertson

Smith, North, Flanigen, Nominated for Directorships

Walter Charles Smith (A '07, M '26, F '40) Pacific district engineer, the General Electric Company, San Francisco, Calif., has been nominated to serve on the AIEE board of directors. Mr. Smith, who was born in Clarkston, Mich., on January 9, 1882, was graduated from the University of Michigan in 1905. In the same year, he entered the testing department of the General Electric Company at Schenectady, N. Y. All subsequent experience has been with that company. In 1907 he was made assistant designer of reactors and railway compensators, and in 1908 he was transferred to Pittsfield, Mass., as chief designer. During his period in Pittsfield he rose to the position of assistant engineer of the transformer engineering department. From 1918 until 1920 he did special investigation work for this department with his headquarters at Denver, Colo., and in 1920 he was made transformer specialist at the San Francisco office. He became assistant engineer in 1931 and chief engineer in 1932. He was appointed engineer of the Pacific district in 1940. Mr. Smith was chairman of the AIEE Pittsfield Section for 1912–13 and of the San Francisco Section for 1933–34. He was chairman of the program committee at the AIEE Pacific convention in San Francisco in 1939 and vice-president of the Pacific District (8) in 1941–42. He is past chairman of the San Francisco Engineering Council and past director of the San Francisco Engineers Club. In 1925 Mr. Smith received the Coffin Award from the General Electric Company for transformer design.

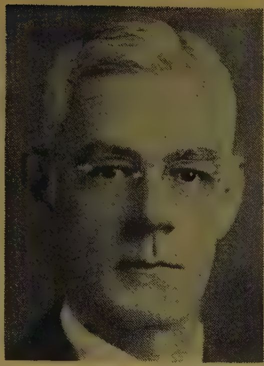
John Rainsford North (A '21, M '29, F '41) assistant chief electrical engineer, Commonwealth and Southern Corporation, Jackson Mich., has been nominated to serve on the AIEE board of directors. Mr. North was born in Cambridge, Mass., on February 20, 1900, and in 1923 received a bachelor-of-science degree in electrical engineering from the California Institute of Technology, Pasadena. During his last year at the California Institute of Technology he was assistant instructor in the electrical-engineering department and after graduating joined the Westinghouse Electric and Manufacturing Company at East Pittsburgh and Sharon, Pa., as student engineer. He became associated with the Commonwealth and Southern Corporation in 1927 as an engineer in the investigations division. In 1927 he was made assistant investigations engineer, in 1931, general engineer, in 1937, general technical engineer, and in 1939, assistant chief electrical engineer. Mr. North was chairman of the AIEE Michigan Section in 1934–35 and chairman of the AIEE Standards committee for the year 1942–43. He has been a member of the protective devices committee, the electric machinery committee, and the committee on the economic status of the engineer, and has served as AIEE representative on the electrical standards committee of the American Standards Association. He is a member of the Edison Electric Institute.

John Monteith Flanigen (A '22, M '25) distribution engineer, plant accounting. Georgia Power Company, Atlanta, has been nominated to serve on the AIEE board of directors. He was born on November 25, 1895, in Athens, Ga., and in 1917 was graduated from the Georgia School of Technology. During the first World War he served as a lieutenant in the United States Army Coast Artillery Corps and upon his discharge in 1919 entered the employ of Henry L. Doherty and Company as a cadet engineer at Toledo, Ohio. After training, he was transferred to Danbury, Conn., as general engineer. In 1920 Mr. Flanigen was with the Cumberland and Westernport Electric Railway, Cumberland, Md., and in 1921 with the Massillon (Ohio) Electric and Gas Company. He entered the employ of the Ohio Public Service Company, Alliance, in 1921 as distribution engineer. In this capacity he designed and put through the rebuilding of practically the entire distribution system of Alliance. In 1927 he joined the Georgia Power Company as assistant superintendent of retail operation, becoming distribution engineer in 1939. Mr. Flanigen was a member of the AIEE committee on protective devices for 1937–38.

W. I. Slichter Renominated for AIEE Treasurer

Walter Irvine Slichter (A '00, M '03, F '12) professor emeritus of electrical engineering, Columbia University, New York, N. Y., has been renominated for the office of AIEE treasurer which he has held since 1930. Professor Slichter was born in St. Paul, Minn., on May 7, 1873, and was graduated from Columbia University with the degree of electrical engineer in 1896. He was associated with the General Electric Company, Schenectady, N. Y., from 1897 to 1904. During this time he spent five years

E. S. Fields



J. M. Flanigen

J. R. North

as assistant to C. P. Steinmetz on a-c machinery design. In 1910 he was appointed professor and head of the department of electrical engineering at Columbia University and has been professor emeritus since 1941. His AIEE activities include representation of the Institute on the board of the Engineering Library and on the Engineering Foundation board and service on the AIEE committee on inter-American engineering co-operation and as AIEE representative on the Joint Committee on Inter-American Co-operation, and service in numerous other committees.

L. R. Gaty (A '39, M '43) formerly assistant electrical engineer, Philadelphia Electric Company, has been appointed acting electrical engineer, of the electrical-engineering division. A graduate of Cornell University, Mr. Gaty had been assistant electrical engineer since 1940. **C. C. Farrell** (A '41) engineer in charge of system planning succeeds Mr. Gaty. Mr. Farrell joined the Philadelphia Company in 1921 and has been superintendent of overhead and underground lines and superintendent of estimating and detailing. **H. A. Dambly** (A '24, F '42) assistant engineer in charge of special investigations has been transferred to the position of engineer in charge of system planning. Mr. Dambly, a graduate of Pennsylvania State College, received his master-of-science degree from Massachusetts Institute of Technology in 1923, the year he joined the Philadelphia Electric Company. **A. H. Kidder** (A '29, M '39) formerly assistant engineer of system planning, transmission, and distribution, replaces Mr. Dambly as assistant engineer in charge of special investigations. Mr. Kidder is a graduate of the Massachusetts Institute of Technology. **F. J. Berger** (A '27) senior engineer, has been named to Mr. Kidder's former position.

W. D. Coolidge (A '10, M '34) vice-president and director of research, General Electric Company, Schenectady, N. Y., has retired. Doctor Coolidge holds the degree of bachelor of science from the Massachusetts Institute of Technology and the degree of doctor of philosophy from the University of Leipzig, Germany. Doctor Coolidge's development of ductile tungsten was an important step in the emergence of the modern incandescent lamp, and he also produced a radically new type of X-ray tube. He is the holder of 83 patents and has a partial interest in many others. He joined the General Electric Company in 1905, became assistant director of its research laboratory in 1908, associate director in 1928, and director in 1932. Among the many honors bestowed upon Doctor Coolidge are the Edison Medal, the Faraday Medal, the Franklin Institute medal, the Hughes Medal, the Rumford Medal, the John Scott award, and the Washington award. He is a member of numerous scientific societies in the United States and Europe and has received the honorary doctor-of-science degree from Union College and Lehigh University.

D. G. Shepherd (M '22) formerly general manager, Electric Specialty Company, Stamford, Conn., has been elected president of the company. A 1902 graduate of Pratt Institute, Mr. Shepherd first was employed as foreman for the Mann Electric Company, New York, N. Y., until 1904. From 1904 to 1906 he was manager of an electrical contracting and repair business in Sandusky, Ohio. After a six-month period with the Western Electric Company, Chicago, Ill., he became experimental and commercial testing engineer and foreman for the Emerson Electric Manufacturing Company, St Louis, Mo. In 1911 he was appointed engineer and general manager of the Electric Specialty Company. **W. H. Haines** (A '17, M '25) sales manager of the company, has been elected vice-president and general sales manager. Mr. Haines received his engineering degree from Columbia University in 1912 and was associated with the Crocker-Wheeler Company, Ampere, N. J., and the Bethlehem Shipbuilding Corporation before he joined the Electric Specialty Company in 1921 as designing and sales engineer. In 1924 he became sales manager.

A. W. K. Billings (A '07, F '13) formerly vice-president of the Brazilian Traction, Light, and Power Company, Ltd., Rio de Janiero, has been elected president of the company. Mr. Billings was graduated from Harvard University in 1895 and received the degree of master of arts in 1896. He joined the Havana Electric Railway Company in 1899 as assistant general manager, later becoming chief engineer of that company and the Havana Central Railroad Company. From 1909 to 1911 he was engineering manager of J. G. White and Company, Inc., New York, N. Y., and thereafter went to Barcelona, Spain, as managing director of the Ebro Irrigation and Power Company, Ltd. During World War I he served as a lieutenant commander in the United States Naval Reserve. Afterwards he became a consulting engineer first in Barcelona and then for the Canadian Engineering Agency, New York. In 1924 he was appointed vice-president of the Brazilian Power Company.

W. L. Everitt (A '25, F '36) director of operational research, Office of Chief Signal Officer, United States War Department, Washington, D. C., has been appointed professor and head of the department of electrical engineering, of the University of Illinois, Urbana. Professor Everitt holds the degrees of electrical engineer from Cornell University, master of science from the University of Michigan, and doctor of philosophy from Ohio State University. He commenced his teaching career in 1924 as instructor at the University of Michigan, Ann Arbor, and in 1926 joined the faculty of Ohio State University, Columbus, as assistant professor. He was named associate professor in 1929 and full professor in 1934. Concurrently with his professorial duties he worked on communication engineering for the American Telephone and Telegraph Company and for the Signal Corps; he is the author of "Communication Engineering."

H. B. Reynolds (M '41) formerly superintendent of motive power of Interborough Rapid Transit division of the New York City Transit System, has been made superintendent of power generation for the entire transit system. Mr. Reynolds first joined the Interborough Rapid Transit Company in 1914 as assistant engineer. After a period of employment elsewhere he returned to the company in 1919 as mechanical engineer. With the consolidation of the city's subway systems in 1940 he became superintendent of motive power for the IRT division. He is the author of several technical papers and articles and a member of the American Society of Mechanical Engineers.

C. R. Hanna (A '24, F '44) manager of the electromechanical department of the Westinghouse Research Laboratories, East Pittsburgh, Pa., has been appointed an associate director of the Laboratories. Mr. Hanna was graduated from Purdue University in 1922 and has been associated with the Westinghouse Company in the development of new apparatus since that time. In 1936 he designed a gyroscopic regulator for steel-mill-roll motors, a basis for the tank-gun stabilizer developed in 1940. For the invention of this device, which enables Allied tanks to fire accurately while in motion, Mr. Hanna received a Presidential Citation in 1942.

A. K. Stricker, Jr. (A '43) principal industrial specialist on the staff of Major General Roger B. Colton in the office of the Chief Signal Officer, Washington, D. C., recently received the exceptional civilian service award, highest civilian commendation of the War Department. Mr. Stricker's citation reads: "In recognition of his outstanding planning and organizational ability in the development of systems which greatly facili-

tated the procurement, storage, packaging, and issue of Signal Corps equipment. By his perseverance and untiring efforts he contributed immeasurably to the Nation's war effort."

J. B. Harris, Jr. (A '17) formerly vice-president, Rumsey Electric Company, Philadelphia, Pa., has been elected president of the company. He was graduated from the Bliss Electrical School in 1911 and at various times was associated with the General Electric Company, the Westinghouse Electric and Manufacturing Company, and the Pittsburgh Transformer Company. In 1920 he became a member of the firm of Harris and Evans (later Harris and Butler), subsequently becoming its president. In 1935 he was made manager of the electrical-equipment department of the Rumsey Company and in 1939 became vice-president.

J. J. Taylor (A '37) formerly assistant chief engineer, Barberton division of the Ohio Brass Company, has been appointed chief engineer. Mr. Taylor was graduated from the University of Alberta, Canada, in 1928 and immediately entered the test course of the Canadian General Electric Company, Peterborough, Ontario, Canada, later becoming a designer in the induction-motor design department. In 1930 he was employed by the Canadian Ohio Brass Company, Niagara Falls, Ontario, and in 1931 joined the Ohio Brass Company in Barberton as test engineer, becoming development engineer in 1931. Since 1943 he had been assistant chief engineer.

C. W. Leihy (A '30, M '38) manager of publications, Electrical Publications, Inc., Chicago, Ill., and formerly colonel in the United States Army, Washington, D. C., has been awarded the Legion of Merit for "services as a member of the Current Section, Operations Division, and later as Chief of Coordination and Reports Section, War Department General Staff, from February 1942 to September 1944." In his latter capacity, Colonel Leihy prepared the official War Department reports of operations which are rendered daily to the President and to the Chief of Staff.

J. H. Hunt (A '07, M '13) formerly director of the new-devices section of the General Motors Corporation, Detroit, Mich., has been elected engineering vice-president–secretary of the Motor Wheel Corporation. A 1905 graduate of the University of Michigan and a former professor at Ohio University, Mr. Hunt had been with the General Motors Corporation since 1920 and had directed its new-devices section since 1932. He holds a number of patents and is the author of several technical articles.

J. M. Trotter (A '33, M '42) formerly electrical engineer with the Fisher body division of the General Motors Corporation, Chicago, Ill., has been appointed vice-president and chief engineer of the Royal Electrical Manufacturing Company, Chicago. A 1932 graduate of the University of Notre Dame, Mr. Trotter was associated with the Commonwealth and Southern Corporation, Jackson, Mich., from 1937 until he joined the General Motors Corporation in 1943.

T. O. Rudd (A '26) sales engineering department, Kerite Insulated Wire and Cable Company, New York, N. Y., has been elected a vice-president of that concern. He received a bachelor-of-science degree from the Sheffield Scientific School, Yale University, in 1924 and then entered the cadet engineering course of the Philadelphia (Pa.) Electric Company. Mr. Rudd joined the staff of the Kerite Company in 1926.

David Sarnoff (M '23) formerly colonel in the United States Signal Corps, has been promoted to the rank of brigadier general. General Sarnoff, who joined the Signal Corps Reserve in 1924, is on leave as president of the Radio Corporation of America. He recently was awarded the Legion of Merit for his services in the reopening of communications in Paris.

R. D. Cutler (A '20) vice-president, the Hartford (Conn.) Electric Light Company, has been elected a director of that company. Mr. Cutler was graduated from Yale University in 1907 and has spent his entire business career with the Hartford Company. He was made a vice-president in 1936.

W. A. Brecht (M '39) manager of transportation engineering, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has been announced as one of seven recipients of the Order of Merit, highest recognition for achievement awarded by the company.

S. B. Hart (A '44) assistant professor of electrical engineering, department of electrical engineering, Swarthmore College, Swarthmore, Pa., has been appointed application and development engineer, industrial electronics, Radio Corporation of America, Indianapolis, Ind.

D. S. MacCorkle (A '30) sales engineer, Habirshaw Division, Phelps Dodge Copper Products Corporation, New York, N. Y., has resigned. Mr. MacCorkle had been with the company for eight years.

A. K. Bushman (M '26) formerly district manager, industrial department, General Electric Company, Chicago, Ill., has been made manager of application and service engineering, in the apparatus department at Schenectady, N. Y.

James Larkin (A '44) district sales manager, Century Electric Company, New York, N. Y., was recently elected president of the Brown Engineering Association of Brown University, Providence, R. I.

OBITUARY ••••

Philander Betts (A '96, M '99, F '13) Belmar, N. J., retired chief engineer of the New Jersey Board of Public Utilities Commissioners and colonel in the United States Army Reserve Corps, died February 6, 1945. Colonel Betts was born on May 28, 1868, in Nyack, N. Y. After his graduation from Rutgers College in 1891, he entered the employ of the Field Engineering Company, New York, N. Y., in the capacity of foreman on electric railway construction. He joined the Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa., in 1893, and in 1895 went to Washington, D. C., as an engineer with the Bureau of Yards and Docks of the Navy Department. Colonel Betts was appointed an instructor in the electrical-engineering department of George Washington University, Washington, in 1901, later becoming head of the department. He became chief engineer of the New Jersey Board of Public Utilities Commissioners in 1910 and remained in that position until his retirement in 1934. During the first World War he rose to the rank of lieutenant-colonel in the Quartermaster Corps of the United States Army. Colonel Betts' AIEE committee memberships include the board of examiners, 1914–16 and 1921–23; economics of electric service, 1914–19 (chairman 1915–17); meetings and papers, 1915–17; and safety codes, 1924–30. He was a member of the American Society of Mechanical Engineers, the Illuminating Engineering Society, American Electric Railway Association, and the New Jersey Society of Professional Engineers and Land Surveyors.

Harold Leigh Huber (M '23) foreign wire relations engineer, operation and engineering department, the American Telephone and Telegraph Company, New York, N. Y., died February 4, 1945. Mr. Huber, who was born on May 5, 1889, in Rockyford, Colo., attended Cornell University. He became a plant engineering inspector for the Chesapeake and Potomac Telephone Company, Baltimore, Md., in 1913 and in 1914 district plant engineer. In 1919, after serving as first lieutenant with the United States Army Signal Corps during the first World War, he returned to the Chesapeake and Potomac Telephone Company as division plant engineer in West Virginia. Mr. Huber was promoted to engineering assistant in 1920, appraisal engineer in 1925, and in 1927 transferred to the American Telephone and Telegraph Company as foreign-wire-relations engineer. He was a member of the United States National Committee of the International Electrotechnical mission and the Standards council of the American Standards Association and was one of the AIEE representatives on the Electrical Standard Committee.

John Franklin Meyer (A '08, M '13) retired, former physicist, Bureau of Standards, Washington, D. C., died October 30, 1944. Born in Penn Hall, Pa., on March 11, 1875, he received a bachelor-of-arts degree from Franklin and Marshall College in 1894, a master-of-arts degree in 1897, and, in 1904 a doctor-of-philosophy degree from the University of Pennsylvania. He was assistant professor of physics at the University of Pennsylvania, Philadelphia, in 1906, and professor of physics at Pennsylvania State College, State College, in 1907. In 1909 he entered the employ of the Westinghouse Lamp Company, Bloomfield, N. J., where he was in charge of research. Doctor Meyer joined the Bureau of Standards in 1913 to do research on public-utility standards of service. He served on various AIEE committees including the lighting and illumination committee and the Standards com-

mittee, and was a member of the Illuminating Engineering Society, the American Physical Society, and the Washington Academy of Science.

John Wright Willison (M '26) operation superintendent, Yorkshire Electric Power Company, Leeds, Yorkshire, England, died December 16, 1944. Mr. Willison was born in 1885 in Cleveland, Ohio. He attended the Manchester School of Technology and in 1903 entered the telegraph department of the Midland Railway Company, Derby, England. In 1905 he transferred to the locomotive department. Mr. Willison became assistant engineer for the Ashington Coal Company, Northumberland, in 1910. He was assistant plant engineer for Palmers Shipbuilding Company, Yarrow on Tyne, in 1911, and assistant district and maintenance engineer for the Newcastle Electric Supply Company, Newcastle on Tyne, in 1912. During the year 1914 Mr. Willison was an assistant engineer for the Prestea Block A Gold Mining Company of West Africa. He entered the employ of the Yorkshire Electric Power Company in 1915 as district engineer, becoming sectional and control engineer in 1916, and superintendent in 1918.

Frank Conant Gobel (A '05) chief ordnance engineer, United States Navy Yard, Brooklyn, N. Y., died September 16, 1944. He was born in Groton, N. Y., January 27, 1882, and was graduated from Cornell University with the degree of mechanical engineer in 1903. After spending the years, 1903 to 1906, on installation work for the Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa., he commenced his career at the United States Navy Yard. He served as electrical draftsman until 1909 when he was named ordnance draftsman and engineer. He became chief ordnance draftsman in 1920, supervising ordnance draftsman in 1929, senior ordnance engineer in 1935, and chief ordnance engineer in 1941.

George A. Hughes (A '17) chairman of the board, Edison General Electric Appliance Company, Chicago, Ill., died September 9, 1944. Mr. Hughes was born on April 14, 1871. From 1897 until 1908 he managed the Hughes Electric Company at Fargo, Bismarck, and Dickinson, N. D., Eveleth, Minn., and Glendive, Mont. Following a year as a manufacturer's agent for electrical apparatus in Chicago, Ill., he became president of the Hughes Electric Heating Company, Chicago. When the Edison General Electric Appliance Company was formed in 1918 he became president of that company, and in 1940 Mr. Hughes was elected chairman of the board.

Joseph L. Vergilio (A '41) sales engineer, Cleveland, Ohio, died October 17, 1944. Mr. Vergilio was born in Italy on April 4, 1893. His early business experience, 1914 to 1918, was as a mechanical engineer and draftsman, the Erie (Pa.) Forge Company. He served in the United States Army until 1920 and after being discharged, he became a sales engineer in Cleveland representing various companies including: the Hickok Electrical Instrument Company, the Esterline-Angus Company, the I-T-E Circuit Breaker Company, and the Cochrane Corporation. Mr. Vergilio was a member of the Cleveland Engineering Society.

Alexander Massey Wilson (A '09, M '18) professor of electrical engineering, University of Cincinnati, Ohio, died August 23, 1944. Professor Wilson was born in Stranraer, Scotland, on August 31, 1876, and received his bachelor-of-science degree from Purdue University in 1901. He joined the staff of the University of Kentucky, Lexington, in 1904 as an assistant professor of electrical engineering and became professor of electrical engineering in 1906. Professor Wilson became associated with the University of Cincinnati in 1911. He was a member of the Illuminating Engineers Society.

Karl Chandler Randall (A '02, M '12) assistant manager, switchboard engineering department, East Pittsburgh, Pa., died December 4, 1944. Mr. Randall was born in Colorado Springs, Colo., in 1874, and was graduated from the University of Nebraska. After one year as assistant in the electrical-engineering department of the University at Lincoln, and one year in Central America, he joined the Westinghouse Electric and Manufacturing Company, Pittsburgh, as transformer engineer in 1904. He became switchboard division engineer in 1911 and manager of the switchboard-engineering department in 1920. In 1936 he was named assistant manager.

MEMBERSHIP • •

Recommended for Transfer

The board of examiners, at its meeting on February 15, 1945, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

Bradt, A. W., general manager and secretary, Hamilton Hydroelectric System, Hamilton, Ont., Canada.

1 to grade of Fellow

To Grade of Member

Adams, A. W., chief of the control section, Bonneville Power Administration, Vancouver, Wash.
Black, C. H., asst. to mgr., engg., General Elec. Co., Philadelphia, Pa.
Caskey, A. D., elec. engr., Public Service Co. of Northern Illinois, Chicago, Ill.
Castellan, G. E., military mechanist (electrical) No. 2 Engineer Base Workshops, R. E., Middle East Forces.
Davis, R. S., division distribution supt., Florida Power & Light Co., Sarasota, Fla.
Dodge, C. C., elec. engr., Stone & Webster Engg. Corp., Boston, Mass.
Doran, J. Y., asst. elec. engr., Toronto Transportation Commission, Toronto, Ont., Canada.
Gilcrease, E. E., field engr., Moloney Electric Co., St. Louis, Mo.
Haberl, H. W., relay protection engr., Quebec Hydro-electric Commission, Montreal, Que., Canada.
Harker, D. C., switchgear engr., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Johnson, J. E., engr., Philadelphia Electric Co., Philadelphia, Pa.
Jones, J. D., division engr., Kellex Corp., Knoxville, Tenn.
Jones, R. W., circuit-design engr., Automatic Electric Co., Chicago, Ill.
Keppy, J. C., district plant engr., Bell Telephone Co. of Canada, London, Ont., Canada.
Morrill, A. R., elec. engr., National Advisory Committee for Aeronautics, Cleveland, Ohio.
Reed, G. M., managing engr., Panel & Equipment Div., General Electric Co., Philadelphia, Pa.
Smith, B. H., electrical design engr., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Summerfield, D. N., staff member, Mass. Inst. of Technology, Cambridge, Mass.
Wheeler, J. W., Product Engr., Sperry Gyroscope Co., Great Neck, N. Y.
White, E. L., asst. to chief engr., Bonneville Power Administration, Portland, Oreg.
Whitney, E. C., electrical design engr., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

21 to grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Any member objecting to the election of any of these candidates should so inform the national secretary before March 31, 1945, or May 31, 1945, if the applicant resides outside of the United States or Canada.

To Grade of Fellow

Bennett, W. H., Inst. of Textile Tech., Charlottesville, Va.

1 to grade of fellow.

To Grade of Member

Barrett, A. C., S.I.D.G., Admiralty, Cardiff, Wales.
Beals, V. H., North Little Rock Elec. Co., No. Little Rock, Ark.
Bolenbaugh, R. K., A. P. Foster Co., Reading, Ohio.
Cady, M. C., U. S. Engineers, Sacramento, Calif.
Corbitt, H. E., Waugh Laboratory, Pasadena, Calif.
Crawford, R. C., General Elec. Co., Philadelphia, Pa.
Delong, A. J., Boeing Aircraft Co., Seattle, Wash.
Diehl, C. J., Automatic Elec. Co., Chicago, Ill.
Dodds, F. C., Mountain States Tel. & Tel. Co., Phoenix, Ariz.
Franklin, A. C., Johnson & Phillips, Ltd., London, England.
Gerlovin, S., United Shipyards, Ltd., Montreal, Que., Can.
Gooding, F. H., Okonite-Callender Cable Co., Paterson, N. J.
Hodgson, R. W., Cons. Engr., Sherman Oaks, Calif.
Hubbard, B. R. (Reelection), Whitney Blake Co., New Haven, Conn.
Johnston, O. E. (Reelection), Bonneville Power Adm., Vancouver, Wash.
Korenblat, A. I., I. K. Elec. Co., Little Rock, Ark.
Korenblat, M. T., I. K. Elec. Co., Little Rock, Ark.
Kratz, J. A., Linde Air Products Co., New York, N. Y.
Laycock, W. E., Standard Tel. & Cables, Ltd., London, England.
Levinton, H. L. (Reelection), Bonneville Pr. Admn., Portland, Oreg.
Lewis, R. W., Boston Edison Co., Boston, Mass.
Lo Buono, A. E., Westinghouse Elec. & Mfg. Co., Huntington, W. Va.
Mangum, G. G., U. S. War Dept., New Orleans, La.
McGinnis, O., Western Union Tel. Co., New York, N. Y.
Montgomery, G. H., E. I. Du Pont & Co., Hanford, Wash.
Muench, G. B., Jeffersonville Boat & Mach. Co., Jeffersonville, Ind.
Randall, C. O., U. S. Rubber Co., New York, N. Y.
Rivard, E. P., U.S.C.G. Academy, New London, Conn.
Rowe, N. O. (Reelection), Hercules Powder Co., Wilmington, Del.
Shields, P. E., Westinghouse Elec. & Mfg. Co., Pittsburgh, Pa.
Watt, R. F., Boeing Aircraft Co., Seattle, Wash.
Wismer, E. W., G. M. Richards & Associates, San Francisco, Calif.
Yeager, L. R., Owens-Corning Fiberglas Corp., New York, N. Y.

33 to grade of Member

To Grade of Associate

United States and Canada

1. North Eastern

Anson, S. M. (Reelection), Westinghouse Elec. & Mfg. Co., Worcester, Mass.
Bordewieck, R. W., Worcester Poly. Inst., Worcester, Mass.
Buxton, P. W., Pub. Serv. Co. of N. H., Nashua, N. H.
Chescavage, A. J., Eastman Kodak Co., Rochester, N. Y.
Clark, F. H., Westinghouse Elec. & Mfg. Co., Boston, Mass.
Dannenberg, W. B., E. B. Badger & Sons Co., Boston, Mass.
de la Torre, J. M., General Elec. Co., Schenectady, N. Y.
Eaton, L. F., Montaup Elec. Co., Fall River, Mass.
Fini, A., Buffalo Niag. Elec. Corp., Buffalo, N. Y.
Fisher, R. M., Jr., General Elec. Co., Schenectady, N. Y.
Goldberg, I. I., General Elec. Co., Pittsfield, Mass.
Humphrey, J. G., Union College, Schenectady, N. Y.
King, E. M., General Elec. Co., Schenectady, N. Y.
Lee, A. J., General Elec. Co., Schenectady, N. Y.
Liebe, H. J., States Co., Hartford, Conn.
Lord, P. E., U. S. Rubber Co., Naugatuck, Conn.
Lund, J. E., Raytheon Mfg. Co., Waltham, Mass.
Macfarlane, G. M., Submarine Signal Co., Boston, Mass.
Maginnis, W. T., Rensselaer Poly. Inst., Troy, N. Y.
May, J. C., Yale Univ., New Haven, Conn.
McNair, E. L., Boston Edison Co., Boston, Mass.
McNamara, J. E., General Elec. Co., Schenectady, N. Y.
Mergendahl, R., Westinghouse Elec. & Mfg. Co., Boston, Mass.
Miller, F. R., United Illum. Co., New Haven, Conn.
Newton, E. C., General Elec. Co., New Haven, Conn.
Nicholson, C. T., Buffalo Niag. Elec. Corp., Buffalo, N. Y.
Parish, H. D., Int. Business Mach. Corp., Buffalo, N. Y.
Parker, S. R., 2nd Lt., U. S. Army, Cambridge, Mass.
Pihl, G. E., Northeastern Univ., Boston, Mass.
Plotkin, L. E., Stromberg-Carlson Co., Rochester, N. Y.

Sanders, E. H., General Elec. Co. Schenectady, N. Y.
Schneider, D. B., General Elec. Co., Schenectady, N. Y.
Shelton, W. R., General Elec. Co., Pittsfield, Mass.
Snyder, F. D., Westinghouse Elec. & Mfg. Co., Boston, Mass.
Stutt, C. A., Stromberg-Carlson Co., Rochester, N. Y.
Woods, H. E., National Aniline & Chem. Co., Buffalo, N. Y.
Zimmerman, C. B., General Elec. Co., Schenectady, N. Y.

2. Middle Eastern

Alexander, W. M., Lear, Inc., Piqua, Ohio.
Bigleson, A., U. S. Navy Yard, Washington, D. C.
Born, W. F., U. S. Navy Dept., Washington, D. C.
Brauburger, R. A., Lafayette College, Easton, Pa.
Burleson, A. J., Jr., U. S. Navy, Washington, D. C.
Burnside, B. H., Bureau of Ships, U. S. Navy Dept., Washington, D. C.
Christian, C. A., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Clarke, W. J., Ohio Box Board Co., Rittman, Ohio.
Coffman, P. R., Lear, Inc., Piqua, Ohio.
Converse, L. B., Cincinnati Ord. Dist., Cincinnati, Ohio.
Curtis, C. H., E. I. du Pont de Nemours & Co., Wilmington, Del.
Desch, J. R., Natl. Cash Reg. Co., Dayton, Ohio.
Dissauer, J. P., Reliance Elec. & Engg. Co., Cleveland, Ohio.
Dugar, V. F., Reliance Elec. & Engg. Co., Cleveland, Ohio.
Frank-Jones, G., Lt., R.N.V.R., Washington, D. C.
George, N. R., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Gray, W., Int. Diesel Elec. Co., Inc., Long Island City, N. Y.
Grebenkemper, C. J., U. S. Naval Res. Labs., Washington, D. C.
Hedene, T. H., Radio Corp. of America, Camden, N. J.
Hesse, J. P., Jr., U. S. Army, Aberdeen Proving Ground, Md.
Hill, J. L., Lear, Inc., Piqua, Ohio.
Holian, A. J., Univ. of Dayton, Dayton, Ohio.
Huddleston, R. H., Jr., Lieut., U. S. Army, Philadelphia, Pa.
Klehfoth, W. G., Fed. Tel. & Radio Corp., Dayton, Ohio.
Klinger, T. M., Ohio Pub. Serv. Co., Elyria, Ohio.
Konick, A. E., Radio Corp. of America, Camden, N. J.
Leonhart, E. C., Carbide & Carbon Chemicals Corp., South Charleston, W. Va.
Lobban, R. A., Picker X-Ray Corp., Baltimore, Md.
Mayhood, H. L., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
McCoy, C. W., Equipment Lab., Wright Field, Dayton, Ohio.
Merkle, E. C., Gen. Motors Corp., Vandalia, Ohio.
Michel, N. B., U. S. Navy Dept., Washington, D. C.
Murakami, T., Swarthmore College, Swarthmore, Pa.
Murray, F. E., Phila. Elec. Co., Plymouth Meeting, Pa.
Musser, R. A., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Nikas, G. J., Philco Radio & Tel. Corp., Philadelphia, Pa.
Parker, J. R., Radio Corp. of America, Camden, N. J.
Postel, H. C., Sperry Gyroscope Co., Inc., Baltimore, Md.
Potter, H. L., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Ralph, E. A., Clark Controller Co., Cleveland, Ohio.
Schaffir, W. B., Picker X-Ray Corp., Cleveland, Ohio.
Scheneman, E. E., Westinghouse Elec. & Mfg. Co., Baltimore, Md.
Schreiner, E. D., U. S. Naval Res. Lab., Washington, D. C.
Stern, J. L., Radio Corp. of America, Camden, N. J.
Sublette, M. C., Ensign, U.S.N.R., Washington, D. C.
Sweetman, C. E., Philco Radio & Tel. Corp., Philadelphia, Pa.
Tatman, O. B. (Mrs.), Leeds & Northrup Co., Philadelphia, Pa.
Teismann, W. P., Cincinnati Water Works, California, Ohio.
Thomas, R. A., General Elec. Co., Erie, Pa.
Torbit, J. G., General Elec. Co., Philadelphia, Pa.
Towne, R. A., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
VanDermark, L. H., Lear, Inc., Piqua, Ohio.
Walker, C. B., I-T-E Circuit Breaker Co., Philadelphia, Pa.
Wayant, R. F., General Elec. Co., Dayton, Ohio.
West, H. H., Ensign, U.S.N.R., Washington, D. C.
Wier, D. D., Jr., Reliance Elec. & Engg. Co., Cleveland, Ohio.
Worley, L. M., U. S. Bureau of Ships, Washington, D. C.

3. New York City

Adams, J. B., Jr., Reeves Sound Lab., Inc., New York, N. Y.
Albright, J. D., Western Elec. Co., Kearny, N. J.
Anthony, T. E., U. S. Rubber Co., Passaic, N. J.
Arnold, E. E., Bell Tel. Labs., Inc., New York, N. Y.
Ballou, F. M., M. B. Cutting Co., Jersey City, N. J.
Beachley, V. B., Westinghouse Elec. & Mfg. Co., Newark, N. J.
Bedworth, R. E., Westinghouse Elec. & Mfg. Co., New York, N. Y.
Behrendt, G. M., Fed. Tel. & Radio Co., New York, N. Y.
Bennett, T. F., Arma Corp., Brooklyn, N. Y.
Berkley, L. S., Burndy Engg. Co., Inc., New York, N. Y.
Boyce, R. P., Fed. Tel. & Radio Corp., East Newark, N. J.
Cann, H. M., Crocker Wheeler Elec. Mfg. Co., Ampere, N. J.
Cavenaugh, D. E., Bell Tel. Lab., New York, N. Y.
Collins, S., U. S. Navy Yard, Brooklyn, N. Y.
Dunn, O. R., U. S. Rubber Co., Passaic, N. J.
Feist, W. E., Cambridge Inst. Co., Inc., Ossining, N. Y.
Goodbar, I., Holophane Co., Inc., New York, N. Y.
Grimmett, R. B., L. I. Lighting Co., Roslyn, N. Y.
Klyce, B. H., Jr., Bell Tel. Labs., Whippany, N. J.
Kups, E. F., Fed. Tel. & Radio Corp., Newark, N. J.
Levander, S. S., Diehl Mfg. Co., Finderne, N. J.
Logue, J. C., Cornell Univ., Ithaca, N. Y.
May, H. F., Teleregister Corp., New York, N. Y.
McCabe, E., U. S. Navy Yard, New York, N. Y.
Miller, D. H., McGraw-Hill Publishing Co., Inc., New York, N. Y.
Palmer, W. E., New York *Times*, New York City, N. Y.
Ruppel, A. E., Bell Tel. Lab., New York, N. Y.
Sanwald, W. D., Weston Elec. Inst. Corp., Newark, N. J.
Schwartz, R. F., Cpl., U. S. Army, Fort Monmouth, N. J.
Shoop, R. M., "Electrical World," New York, N. Y.
Spillane, G., General Elec. Co., New York, N. Y.
Tappan, T. C., Int. Gen. Elec. Co., New York, N. Y.
Young, S. B., Cambridge Inst. Co., Ossining, N. Y.

4. Southern

Anderson, E. H., George G. Sharp, New Orleans, La.
Barkin, I. J. (Reelection), Tenn. Val. Auth., Knoxville, Tenn.
Corneliussen, E., Tenn. Val. Auth., Knoxville, Tenn.
English, J. C., Graybar Elec. Co., Inc., Little Rock, Ark.
Ferguson, D. J., Jr., Tenn. Valley Auth., Knoxville, Tenn.
Fink, F. P., Watson Flagg Engr. Co., Knoxville, Tenn.
Fletcher, V. V., Aluminum Co. of America, Malvern, Ark.
Foster, C. M., U. S. Engineers, Little Rock, Ark.
Frischhertz, R. E., Avondale Marine Ways, Avondale, La.
Goodson, A. B., Naval Operating Base, Norfolk, Va.
Graham, R. L., Lt., U.S.N.R., Greenville, S. C.
Harvill, R. L., Harvill-Byrd Elec. Co., Little Rock, Ark.
Hunter, J. A., Westinghouse Elec. Supply Co., Memphis, Tenn.
Jacobs, P. B., Jr., Tenn. Eastman Corp., Oak Ridge, Tenn.
Johnson, B. E., Higgins Industries, New Orleans, La.
Kimm, E. G., U. S. Engineer Office, Little Rock, Ark.
Landers, A. F., Westinghouse Elec. & Mfg. Co., New Orleans, La.
Lewis, W. A., Jr., Aluminum Co. of America, Malvern, Ark.
Lyons, W. H., Jr., Southern Bell Tel. & Tel. Co., Atlanta, Ga.
Monson, D. J., N.A.C.A., Langley Field, Va.
Newland, L. E., City Electrician, Little Rock, Ark.
Ramler, W. J., Tenn. Eastman Corp., Oak Ridge, Tenn.
Raphael, R., Carbide & Carbon Chemical Corp., Oak Ridge, Tenn.
Ryan, J. C., Westinghouse Elec. & Mfg. Co., New Orleans, La.
Sale, H. C., Higgins Industries, Inc., New Orleans, La.
Strum, P. D., N. C. State College, Raleigh, N. C.
Turregano, P. J., Jr., Southwestern La. Inst., Lafayette, La.

5. Great Lakes

Bank, M. L. (Reelection), Commonwealth Edison Co., Chicago, Ill.
Bellafiare, J. P., Mich. Tool Co., Detroit, Mich.
Bernhard, C. W., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Cooper, S. E., Zenith Radio Corp., Chicago, Ill.
Duncan, V. W., Farnsworth Tel. & Radio Corp., Fort Wayne, Ind.
Fife, J. L. (Reelection), Commonwealth Edison Co., Chicago, Ill.
Fitzgerald, J. A., General Elec. Co., Fort Wayne, Ind.
George, W. A., Pub. Serv. of Northern Ill., Waukegan, Ill.
Ingram, E., C. G. Conn Ltd., Elkhart, Ind.
Kavlock, C. J., Commonwealth Edison Co., Chicago, Ill.
Larson, W. M., Control Corp., Minneapolis, Minn.
Martindell, C. C., Western Elec. Co., Cicero, Ill.
Mayr, F. J., Allis-Chalmers Mfg. Co., West Allis, Wis.
Polk, H. K., Western United Gas & Elec. Co., Aurora, Ill.
Richardson, B. R., Western United Gas & Elec. Co., Aurora, Ill.
Sandberg, M. C., Control Corp., Minneapolis, Minn.
Sangdahl, A. D., Delta-Star Elec. Co., Chicago, Ill.
Schaupner, A. P., Spaulding Elec. Co., Detroit, Mich.
Schroeder, A. F., Buell & Winter, Engrs., Sioux City, Iowa.
Seely, R. E., General Elec. Co., Fort Wayne, Ind.
Spaulding, J. G., Jr., Spaulding Elec. Co., Detroit, Mich.
Spaulding, R. C., Spaulding Elec. Co., Detroit, Mich.
Toombs, J. E. (Reelection), Ind. Gen. Serv. Co., Marion, Ind.
Van Guilder, W. (Reelection), Precision Scient. Co., Chicago, Ill.
Walker, B. G., Control Corp., Minneapolis, Minn.
Williams, H. C., Commonwealth Edison Co., Chicago, Ill.

6. North Central

Fick, W. A., Mountain States Tel. & Tel. Co., Denver, Colo.
Kemper, V. C., Jr., Gates Rubber Co., Denver, Colo.
Muench, R. R., Amer. Tel. & Tel. Co., Denver, Colo.
Parker, E. H., Amer. Tel. & Tel. Co., Denver, Colo.
Stephens, W. J., Public Serv. Co. of Colo., Denver, Colo.

7. South West

Alberti, A. C., Pub. Serv. Board, San Antonio, Texas.
Arnold, H. D., Emerson Elec. Mfg. Co., St. Louis, Mo.
Ballman, F. C., Baldor Elec. Co., St. Louis, Mo.
Clayton, J. C., Todd-Galveston Drydocks, Inc., Galveston, Texas.
Elliott, E. E., Emerson Elec. Mfg. Co., St. Louis, Mo.
Gettinger, H. J., Emerson Elec. Mfg. Co., St. Louis, Mo.
Jenkins, C. L., R. F. Taylor, Cons. Engr., Houston, Texas.
Lindberg, C. A., Emerson Elec. Mfg. Co., St. Louis, Mo.
Raithel, R. I., Emerson Elec. Mfg. Co., St. Louis, Mo.
Shipp, C. M., Westinghouse Elec. & Mfg. Co., St. Louis, Mo.
Thompson, W. M., El Paso Elec. Co., El Paso, Texas.

8. Pacific

Axe, F. H., Cons. Vultee Aircraft Corp., San Diego, Calif.
Barry, L. S., General Elec. Co., San Francisco, Calif.
Cooper, R. L., Western Pipe & Steel Co., San Pedro, Calif.
Depew, B. W., General Elec. Co., San Francisco, Calif.
Dobbins, A. H., Calif. Shipbuilding Corp., Wilmington, Calif.
Foote, S. H., Arizona Broadcasting Co., Tucson, Ariz.
Frazee, H. H., N.A.C.A., Moffett Field, Calif.
Gleisberg, A. E., Pacific Gas & Elec. Co., San Mateo, Calif.
Goetz, J. A. (Reelection), Southern Pacific Co., San Francisco, Calif.
Harrington, K. D., Cutler-Hammer, Inc., Los Angeles, Calif.
Karpinen, T. M., Sacramento Air Tech. Serv. Com., Sacramento, Calif.
Lawler, W. L., Engr. Procurement Div., USASOS, San Francisco, Calif.
Manildi, J. F., G. M. Giannini & Co., Pasadena, Calif.
Martin, G. J., Southern Calif. Tel. Co., Los Angeles, Calif.
Mazzola, E. P., Gardner Elec. Mfg. Co., Emeryville, Calif.
Nourse, M. S., N.A.C.A., Moffett Field, Calif.
Powell, W. W., Coast Elec. Co., San Diego, Calif.
Rich, K. C., Pacific Gas & Elec. Co., San Francisco, Calif.
Schmidt, D. C., Univ. of Calif., San Diego, Calif.
Snow, R. G., 11th Naval Dist., San Diego, Calif.
Tanner, A. R. (Reelection), General Elec. Co., San Francisco, Calif.
Templin, K. W., Byron Jackson Co., Huntington Park, Calif.
Ward, B. D. (Reelection), Army Base, Oakland, Calif.
Watson, C. J., Calif. Shipbuilding Corp., Terminal Island, Calif.

9. North West

Bay, F. H., Pacific Tel. & Tel. Co., Portland, Oreg.
Brazier, E. E., Gen. Elec. Supply Corp., Salt Lake City, Utah.
Cropley, M. L., Puget Sound Pr. & Lt. Co., Seattle, Wash.
David, G. A., Willamette Iron & Steel Corp., Portland, Oreg.
Engels, P. R., Jr., E. I. du Pont de Nemours, Hanford, Wash.
Harrington, O. J., Portland Gen. Elec. Co., Portland, Oreg.
Knorr, A. C., Northwestern Elec. Co., Portland, Oreg.
Mashino, L. L., Montana Pr. Co., Great Falls, Mont.
Paul, B. W., Bonneville Pr. Adm., Vancouver, Wash.
Radcliffe, J. H. (Reelection), Montana Pr. Co., Great Falls, Mont.
Stangell, P. A., Portland Gen. Elec. Co., Portland, Oreg.
Stewart, G. H., City of Spokane, Spokane, Wash.
Whisler, H. L., Portland Gen. Elec. Co., Portland, Oreg.

10. Canada

Bagley, P. E., E. Long, Ltd., Orillia, Ont., Can.
Brian, J. M. (Reelection), RCA Victor Co. Ltd., Montreal, Que., Can.
Carberry, G. E., Ferranti Elec., Ltd., Mt. Dennis, Ont., Canada.
Deane, R., Cemco Elec. Mfg. Co., Vancouver, B. C., Can.
Geary, B. H., Can. Gen. Elec. Co., Ltd., Toronto, Ont., Can.
Doak, F. C., Lower St. Lawrence Power Co., Rimouski, Que., Can.
Hudson, A. C., Research Enterprises Ltd., Leaside, Ont., Can.
Lowry, H. B., Manitoba Tel. System, Winnipeg, Man., Can.
MacCrae, V. C., Lt. Cmdr., R.C.N.V.R., Esquimalt, B. C., Can.
Page, J. H., Orillia Water, Lt. & Pr. Comm., Orillia, Ont., Can.
Shanks, V., Sangamo Co., Ltd., Leaside, Ont., Can.
Thompson, R. A., Goodyear Tire & Rubber Co., New Toronto, Ont., Can.
White, L. G., Dominion Magnesium, Ltd., Haley, Ont., Can.
Willey, G. E., N. Slater Co., Hamilton, Ont., Can.

Elsewhere

Chandra, B. K., South Wales Power Co., London, England.
Corlett, E. G., Lt., H. M. Forces, Bombay, India.
Gruenberg, H., Univ. of B. C., Vancouver, B. C., Can
Iqbal, M., Military Engg. Serv., South East Asia Command, India.
Olea, N., M., Petroleos Mex., Mexico, Mex.
Pardo, I. S., Soc. Electro Mecanica, Mexico, Mex.
Paredes, G., A., Cia Impulsora de Emp. Electricas, Mexico, Mex.
Scheffel, G. E., Electromedidor S.R.L., Buenos Aires, Arg., S. A.
Sinotte, J. L., Cons. Paper Corp., Ltd., Cap de la Madeleine, Que., Can.
Villafana, P., J., Electrica Chapala S. A., Guadalajara, Mex.

Total to grade of Associate
United States and Canada, 246
Elsewhere, 10

Inventors Council Seeks Solutions to Navy Department Problems

The National Inventors Council recently released a list of inventive problems for which the United States Navy Department is seeking solutions. Included in the list are the following items of possible interest to electrical engineers:

1. A beach-marker light, to be visible from 5,000 yards at sea, with rechargeable or nondeteriorating battery and weighing not more than five pounds.

2. A device for transmitting rotary motion through a moistureproof barrier to be applied to control-knob shafts on radio equipment provided with immersion-proof cases, generator shafts on field telephones equipped with immersion-proof cases, and generator shafts for hand-cranked power supplies for field radio equipment. The device should prevent entrance of water or moisture vapor when immersed to a depth of ten feet, should offer a minimum of frictional opposition to rotary motion, should be small in relation to the equipment to which it is applied, should have ample power-transmission capability, and should be applicable to existing equipment with a minimum of modification.

3. Waterproof jack for microphone, headphone, and key jacks for telephone equipment which would prevent water or moisture vapor from penetrating equipment, even when immersed to a depth of ten feet. The jack should be capable of being cleaned and dried without tools and should accommodate standard plugs.

4. A directional-drum lens for use by the United States Coast Guard in its lighting aids to navigation. The Coast Guard now uses 200-millimeter Fresnel-type drum lenses which provide a 360-degree fan beam of uniform candlepower on the horizon plus an auxiliary spotlight when additional intensity is required. The need is for a single lens which will permit the function of both lights from a single source but whose over-all dimensions will be that of the present lens.

5. A single-unit range light which will indicate with a reasonable degree of sensitivity a vessel's lateral deviation from the center line as it proceeds along a narrow channel. The device must be inexpensive and low in power consumption.

6. A polyphase a-c integral-horsepower motor up to 50 horsepower, whose inrush current does not exceed the running current and whose starting torque equals the running torque.

7. A small portable field-strength meter about the size and weight of a "walkie-talkie" for rapid checking of radio field intensities in the vicinity of radio transmitting stations. The instrument must be simple to use and accurate within plus or minus ten per cent. Frequency range desired is 100 to 20,000 kilocycles, and desired field-intensity range is from 10 to 1,000 millivolts per meter.

8. Radio antennas up to 300 feet in height that can be set up by unskilled ground crews. Very light alloys and special rigs for rapid erection by a ground crew without climbing are desired, in addition to ability to dismantle or collapse into packages not exceeding 20 feet in length. Insulated-base vertical antennas are preferable.

9. Small aircraft-type d-c motors without commutators, slip rings, or any other moving contact arrangements, so as to eliminate service difficulties with commutators and electrical noise produced thereby.

10. A precision twin-triode vacuum tube with the general characteristics of the current 6SN7 type plus additional precision features. It shall be completely nonmicrophonic; the mutual conductance of the two sides, after a 15-minute warm-up, shall be equal over the normal operating range to within plus one per cent; these characteristics are to be maintained over an ambient-temperature range of from +80 to −40 degrees centigrade. It would be possible to produce this tube by mass-production methods with not more than ten per cent rejections.

11. An expendable, compact, lightweight, rugged, mechanical device to permit successive closures of up to eight electric circuits with a time interval between closures of about 0.2 to 0.3 second.

12. A small, fast-acting, double-action solenoid to operate on 28 volts direct current with a stroke of about 0.5 with a 20-pound pull (or push) at condition of maximum air gap. The plunger should "seat" at each end of travel and very probably would have to be an electromagnet whose polarity would reverse at each end of travel.

13. A method of welding high-pressure piping without the aid of backing straps or with back straps which would be soluble in a harmless solution which could be introduced in the pipe before putting same into service.

14. A method of welding light-gage aluminum. This is of particular interest since aluminum lifeboats and life rafts are currently of riveted construction because of the lack of a satisfactory method of welding.

Suggested solutions should be prepared in sketch and description form and submitted to the National Inventors Council, Department of Commerce, Washington 25, D. C.

Seized Enemy Patents Described in Abstracts

Publication of two sets of Abstracts or short descriptions of 45,000 alien-owned United States patents seized by the Alien Property Custodian of the United States Government has been announced by James E. Markham, the Custodian. Licenses to most of the patents, which cover practically every field of manufacture, are available to American citizens at a fee of $15 per patent and are good for the life of the patent.

The Mechanical and Electrical Abstracts (about 37,000 patents) are bound in four volumes comprising approximately 4,000 pages of short descriptions and illustrative drawings and include a 48-page index. The remaining 8,000 patents are classified under Chemical Abstracts. Either set may be obtained for $25 from the Office of Alien Property Custodian, 311 Field Building, Chicago 3, Ill.

If complete sets of abstracts are not desired, sections or classes dealing with any one subject are obtainable at proportional cost. An index showing the section or class titles and prices may be procured free-of-charge from the Alien Property Custodian.

Transmitter–Receiver Designed for Lifeboat Use

A transmitter–receiver for use in lifeboats, equipped for two-way manual radiotelegraph and radiotelephone and for automatic radiotelegraph transmission, which can be operated by nonskilled men, has been announced by the United States Maritime Commission. The radiotelephone will enable occupants of lifeboats so equipped to maintain communications between lifeboats.

The transmitter–receiver will operate on pretuned international distress frequency of 500 kilocycles and on the high frequency adopted by the air/sea rescue program.

The transmitter–receiver is operable entirely by the use of a hand-powered generator. It is entirely waterproof and embodies the use of balloon and kite antennas enabling an average transmitting range ten times that obtainable with the present lifeboat transmitter on 500 kilocycles and a range above 1,000 miles when used on the high-frequency band.

Radio Powered by Two Watts Available in Holland

A new radio set, which uses only two watts of electricity in comparison to the 10- to 20-watt requirements of older models, soon will be obtainable in liberated Holland, according to Aneta, Netherlands news agency. Cost of the radio will be 45 guilders ($24.30).

Because of the acute shortage of electricity, Hollanders who were able to retrieve their radios after the liberation were forced to curtail their usage. For this reason, demand for the new radio, which requires much less power, is expected to be widespread.

OTHER SOCIETIES

Tau Beta Pi—Eta Kappa Nu Hold Joint Meeting

A joint dinner meeting of Tau Beta Pi and Eta Kappa Nu, honorary engineering fraternities, was held January 22, 1945, during the AIEE winter technical meeting in New York, N. Y. Vladimir Karapetoff (F '12) was guest of honor and delivered an address on "Fundamental Concepts of Relativity." He was introduced by Ernst Weber (F '34) professor and head of the graduate electrical-engineering department, Polytechnic Institute of Brooklyn, Brooklyn, N. Y., who outlined the high lights in the speaker's career. Professor Karapetoff became professor emeritus of electrical engineering of Cornell University in 1939, after 35 years at the university and was engaged in activities related to the war when he was afflicted by failing eyesight, culminating in almost total blindness in 1943.

Professor Karapetoff presented his subject in a nonmathematical manner by showing how two observers moving relative to each other would obtain different results in measurements of time and length because of the relative motion. He predicted that the importance of the work of Einstein will become apparent to future generations, in accordance with the pattern of history which shows that the significance of the work of other scientists, such as Newton, was not appreciated widely in their day. In one of several interesting diversions from the main subject, Professor Karapetoff compared a political system to a gyroscope; pressure may be applied with the intention of moving the system in a certain direction, but like the gyroscope the system will move in a new direction at right angles to the pressure, with an irresistible force.

V. L. Dzwonczyk (M '43) assisted in the presentation of illustrative charts. Nearly 200 members and guests were present.

New IRE London Branch Meets; Elects Officers

Election of G. A. Woonton, professor, University of Western Ontario, as chairman was announced recently as a result of the first official meeting of the London, Ontario, Canada, branch of the Institute of Radio Engineers. The meeting took place on November 24, 1944, culminating a year of organizational work.

Other officers elected were: J. R. Bach, manager of the meter department, Sparton Radio, London, as vice-chairman; Robert Wilton, flight lieutenant, Royal Canadian Air Force, Clinton, Ontario, as secretary-treasurer; and as committee chairmen, R. C. Dearle, professor, University of Western Ontario, education; W. J. Blackburn, president, The Free Press, publicity; Burwell Graham, chief engineer, Sparton Radio, London, membership; and K. R. Patrick, wing commander, Royal Canadian Air Forces, Clinton, meeting and papers.

1945 Officers Elected by AIME

Harvey Seeley Mudd was elected president of the American Institute of Mining and Metallurgical Engineers, New York, N. Y., for the year 1945 recently.

Donald H. McLaughlin and Leo F. Reinartz were elected vice-presidents and directors for three-year terms. Others elected directors for three-year terms are: C. H. Benedict, Robert H. Morris, J. C. Nicholls, Clyde E. Weed, Eugene A. White, and W. E. Wrather.

Ice Breakers Add Bow Propeller

A bow propeller supplements the two customary stern propellers in this new-type ice breaker. Driven by a Westinghouse 3,300-shaft-horsepower motor, the propeller can turn in either direction to build up a bow wave for cracking heavy ice or to pull water from under the ice, making it break under its own weight. Each of the stern propellers is driven by a 5,000-horsepower motor, and power for all three is provided by six 1,375-kw Diesel-driven generators. The generators are operated in parallel, and the speed of the propulsion motors is controlled by gradually raising the generator excitation to about 75 per cent of maximum excitation while the engines are run at minimum speed and the motors are excited at minimum value. For higher speeds the engine is raised to maximum speed, and, at the same time the generator excitation is increased from 75 per cent to normal. The motor field is controlled by an automatic current regulator which causes the absorption of the maximum available engine output. Under ice-breaking conditions overloading is prevented by a torque-limiting governor which automatically reduces engine speed

INDUSTRY . . . . .

Committee Is Appointed to Advise on Standards

A committee of eight industrial executives, with C. E. Wilson, president, the General Electric Company, as chairman, has been appointed by the Secretary of Commerce to advise the Department of Commerce and the American Standards Association on future plans for standards work. Also serving on the committee are F. M. Feiker (F '42) dean of engineering, George Washington University, and F. B. Jewett (F '12) president, the National Academy of Sciences.

The appointment is the result of a conference of 50 business leaders held in New York, January 12, 1945, at the invitation of the Secretary of Commerce, to make suggestions to him regarding the relative roles which should be played by the Government and industry in standards activities. At that time it was recommended that industry should provide a strong leadership in the development of national standards, that this should be done in full co-operation with the Government, and that arrangements should be made for broader participation of industry, both organized groups and individual companies, in the work of the American Standards Association. Among other actions taken were formal resolutions that the National Bureau of Standards strengthen its work on the fundamental standards and methods of measurement and on the development of data needed in standardization activities. It also was resolved that in the field of consumer goods, as in other fields, each Standard approved by the ASA must represent the work of those groups which are concerned with its scope and provisions, and no effort must be made to impose Standards on them.

Slide Film Course in Resistance Welding Control. A resistance-welding-control training course, prepared by Westinghouse Electric and Manufacturing Company for its own employees, is being made available to others as a result of requests from engineering groups and individuals interested in the subject. The seven-lesson training course, consisting of 35-millimeter slide sound films, lesson books, quiz book, and an instructor's manual, may be ordered from C. R. Riker, Westinghouse Electric and Manufacturing Company, 306 Fourth Avenue, Pittsburgh, Pa.

Farm Organization Receives Gift. The presentation of a check for $10,000 to the Future Farmers of America, a national organization designed to stimulate the interest and knowledge of farm boys in electricity and its application to the farm, has been announced by the General Electric Company, Schenectady, N. Y. The farm youth organization, which was organized in 1928, has 6,900 active chapters in high schools of the country with an active membership of 240,000 boys.

JOINT ACTIVITIES

ASA Approves New Standard for Sound Level Meters

A new American Standard for sound level meters, superseding a tentative Standard originally issued in 1936, has been approved by the American Standards Association. These meters are used for measuring the intensities of noise and other sounds in order to evaluate their relative effect on the ear.

Work on the new Standard was carried out by a committee of technical experts under the direction of the Acoustical Society of America and brings the tentative standard up to date in accordance with developments in acoustical practice in the sound-measurement field. The standard now includes design objective and tolerance curves for flat response-frequency characteristics of sound level meters and slight revisions in the previous curves for 40- and 70-decibel equal-loudness contours. Data from which the design objective response curves have been plotted are also included.

ECPD to Be Represented On Education Committee

Intended participation in the activities of the Citizen's Federal Committee on Education, recently established to present the layman's point of view on American education, has been announced by the Engineers' Coun-

cil for Professional Development, although a representative has not been chosen as yet.

The Citizen's Committee has been organized to act in an advisory capacity to the Commissioner of Education on policies and on programs of service to education to be carried on by the United States Office of Education. The Committee will meet two or three times each year, and will consist of three persons each from the fields of labor, business, agriculture, manufacturing, and the professions. Also represented will be veterans and service clubs and religious groups.

ECPD Issues Annual Report

The Engineers' Council for Professional Development has announced the issuance of its 12th Annual Report for the year ending September 30, 1944. The report, which is available in booklet form, covers the chairman's report to the Council, reports of the various committees, as well as of the representatives of constituent organizations, and the financial statement for the year. It also includes a list of officers, representatives, and committee personnel; the charter and rules of procedure; and an inventory of publications available through the ECPD.

The ECPD report may be obtained for 25 cents through the secretary of ECPD, 29 West 39th Street, New York 18, N. Y.

EDUCATION . . .

Michigan College Offers Scholarships. Twenty-five additional scholarships for properly prepared and accredited foreign students are now available at the Michigan College of Mining and Technology. These scholarships supplement the previous plan under which one scholarship was offered for each province of Canada and one for each Latin-American nation. Under the new plan students from any foreign country are eligible, and each nation or province is not limited to a single scholarship.

Institute of Industrial Research Organized by University

Organization of the University of Louisville Institute of Industrial Research, a nonprofit corporation which will engage in engineering and scientific research for industrial and private clients on a contract basis, has been announced by the board of trustees of the university.

The institute is the outgrowth of the division of industrial research in the Speed Scientific School, which during the past few years has carried on limited contract research for industry. The new organization, in addition to employment of a small permanent technical staff from different scientific and technical fields, will depend for its assistance in supervision on selected staff members of the engineering and scientific faculty. The research work will be carried on by graduate fellows. The institute will be housed in a new research building, and in addition, will use facilities of the engineering laboratories.

The officers are:

Chairman of the board of managers, E. W. Jacobsen, president of University of Louisville.

President, F. L. Wilkinson, Jr., dean of Speed Scientific School.

Director and Vice-President, R. C. Ernst, professor of chemical engineering.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Calculating Antenna Radiation Patterns

To the Editor:

R. W. Cronshey is to be congratulated on his article, "Calculating Antenna Radiation Patterns," (*EE, Sept '44, pp 331–4*). It gives a semigraphical solution to the problem which is easy to understand and to use, thus making it applicable for classroom use as well as to industrial problems.

However, one error should be noted. At the bottom of the first column on page 332, the author states that the voltage induced (that is, the field strength produced) by two transmitting antennas, N and A, will be directly proportional to the ratio of the radiated powers. This is incorrect, for the field strengths are directly proportional to the ratio of antenna *currents*, or to square root of the power ratio.

Thus in the equation for E_P near the top of column 2 of page 332, the *square root* of each of the power ratios should be taken. Also, a term should be included in the first bracket to account for the field strength due to the radiation from antenna A. The corrected equation then would be

$$E_P = E_A \times \sqrt{\begin{aligned}&\left\{1+\sqrt{\frac{P_B}{P_A}}\cos\left[\theta_B-360d_B\cos(\beta_B-\phi)\right]+\sqrt{\frac{P_C}{P_A}}\cos\left[\theta_C-360d_C\cos(\beta_C-\phi)\right]+\sqrt{\frac{P_D}{P_A}}\cos\left[\theta_D-360d_D\cos(\beta_D-\phi)\right]\right\}^2+\\&\left\{\sqrt{\frac{P_B}{P_A}}\sin\left[\theta_B-360d_B\cos(\beta_B-\phi)\right]+\sqrt{\frac{P_C}{P_A}}\sin\left[\theta_C-360d_C\cos(\beta_C-\phi)\right]+\sqrt{\frac{P_D}{P_A}}\sin\left[\theta_D-360d_D\cos(\beta_D-\phi)\right]\right\}^2\end{aligned}}$$

If these corrections are carried over to Table I of the article, column 4 should have the heading $\sqrt{P_N/P_A}$. The ratio $\sqrt{P_N/P_A}$ for antenna D becomes one-fourth. In Table II the square-root sign should be inserted in the headings, and for antenna D

$$\sqrt{\frac{P_N}{P_A}}\sin = 0.22$$

and

$$\sqrt{\frac{P_N}{P_A}}\cos = 0.12$$

This makes $Y = -1.68$, and $X = 0.57$.

Then $\dfrac{E_P}{E_A} = \sqrt{(0.57)^2+(1.68)^2} = 1.77$

in the equation below.

H. L. KRAUSS (A '42)

(Assistant professor of electrical engineering, Yale University, New Haven, Conn.)

To the Editor:

Professor Herbert L. Krauss is right when he says that the statement in my article that the induced voltages vary as the ratio of the radiated powers is incorrect. They vary as the *square root* of the ratio of the radiated powers. Consequently, everywhere that the term P_N/P_A is shown, it should be $\sqrt{P_N/P_A}$ instead.

Professor Krauss is also correct in stating that the numeral one (1) has been omitted from the equation for the four-element array. It is wondered if anyone has noticed also that the same numeral one (1) has been omitted from the two radicals which are equated to E_0. For these omissions the author assumes full responsibility. The entire solution was conceived and developed from the graphical standpoint. Only when attempting to offer a rigorous proof were the mathematics introduced. It was here that these terms were erroneously dropped.

It is pointed out that the errors noted above all are errors in algebra and in no way invalidate the principles actually pertaining to the graphical solution itself.

It might be pointed out also that Professor Krauss is in error in his remarks regarding the changing of the values arrived at in the sample problem of Tables I and II. If, as explained here and in the professor's letter, the square-root sign were to be placed around the power ratio in the heading of column 4 of Table I and in the headings of columns 3 and 5 of Table II, the values indicated would in no way need to be altered. Thus, the change of value for antenna D which Professor Krauss quoted will be seen to be the result of one too many square-root signs.

Professor Krauss is to be commended for his close attention to the details of the

mathematical solution. This assistance in perfecting a rigorous proof for the graphical solution is deeply appreciated.

RAYMOND W. CRONSHEY (Student member)

(Second lieutenant, Signal Corps, United States Army, Presque Isle, Me.)

NEW BOOKS • • •

The following new books are among those recently received from the publishers. Books designated ESL are available at the Engineering Societies Library; these and thousands of other technical books may be borrowed from the library by mail by AIEE members. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books. All inquiries relating to the purchase of any book reviewed in these columns should be addressed to the publisher of the book in question.

Electron-Optics. By Paul Hatschek. Translated by Arthur Palme. American Photographic Publishing Company, Boston, Mass., 1944. 161 pages, illustrated, $9^1/_4$ by 6 inches, $3.

This new edition is a translation of a book first published in 1937 in Germany and the translator has added a chapter on the progress made in the field of electronics in the interim. The book imparts the fundamentals of electronics without resorting to mathematics. The descriptions and explanations of electronic phenomena are devised to inculcate a broad general idea of their underlying principles coupled with a historical perspective of the subject as a foundation for understanding electronic applications as they become more widespread.

Testing of Engineering Materials. By C. W. Muhlenbruch. D. Van Nostrand Company, Inc., New York, N. Y., 1944. 200 pages, illustrated, $9^1/_2$ by $6^1/_2$ inches, cloth, $2.75. (ESL.)

This book is intended as a text for a one-semester laboratory course for engineering students. Through comprehensive testing of a variety of materials and a careful analysis of the results of the tests, it aims to give the student, a clear picture of those properties that can be illustrated most readily in the testing laboratory and to help him acquire an understanding of the physical properties of the common engineering materials and their possibilities and limitations.

Selected Papers of William Frederick Durand. The Durand reprinting committee, California Institute of Technology, Pasadena, Calif., 1944. Paged in sections, 11 by $8^1/_2$ inches, fabrikoid, $2.50. (ESL.)

Seventeen selected papers of William F. Durand, from 1896 to 1940, have been reprinted in commemoration of the 85th anniversary of his birth. The subject matter is varied, ranging from aerodynamics to philosophical considerations of science and engineering. A brief biographical sketch precedes the papers, and a bibliography of published works concludes the book.

Mitteilungen aus der Versuchsanstalt für Wasserbau an der Eidg. Technische Hochschule in Zürich, Nr. 4. Theoretische Grundlagen der Fluss- und Wildbachverbauungen. By R. Müller. Verlag AG. Gebr. Leemann and Company, Zurich, Switzerland, 1943. 193 pages, illustrated, 9 by 6 inches, paper, 12 Swiss frs. (7.20 rm.). (ESL.)

This publication summarizes the results of the studies of the movement of detritus which have long had the attention of the hydraulic laboratory of the Zurich technical high school. It presents the available knowledge of theoretical principles and shows how these may be applied practically in the regulation of rivers and torrents.

Radio Amateur's Handbook. 21st edition 1944. Published by the American Radio Relay League, West Hartford, Conn. 480 pages, illustrated, $9^1/_2$ by $6^1/_2$ inches, paper, $1. (ESL.)

This standard manual of amateur radio communication, revised annually, consists of two main parts. The principles and design section have been enlarged considerably in the present edition, particularly the chapters on fundamentals and vacuum-tube theory. The construction and data section includes a new chapter on carrier-current communication; and information on some 50 new tubes has been added to the classified vacuum-tube data tables. War emergency radio service is dealt with separately.

Physics. (United States Naval Academy edition.) By E. Hausmann and E. P. Slack. D. Van Nostrand Company, Inc., New York, N. Y., 1944. 857 pages, illustrated, $8^1/_2$ by $5^1/_2$ inches, cloth, $5.50. (ESL.)

The essentials of physics are presented clearly and logically. Numerous problems are worked out to illustrate the application of the principles to practical use. A great many problems are provided for solution. This edition has been prepared for the United States Naval Academy, and the text arranged to meet classroom needs there. The revision has been done by the teaching staff of the Academy.

Ultrahigh-Frequency Radio Engineering. By W. L. Emery. Macmillan Company, New York, N. Y., 1944. 295 pages, illustrated, $8^3/_4$ by $5^1/_2$ inches, cloth, $3.25. (ESL.)

Intended for electrical-engineering students with a background in elementary communication and electronics, this text is confined to basic principles. Emphasis has been placed on the discussion of the component parts of ultrahigh-frequency systems. The problems and experiments included provide a comparison between theoretical and experimental results. A list of references accompanies each chapter.

Technique of the Terrain. By H. A. Musham. Reinhold Publishing Corporation, New York, N. Y., 1944. 228 pages, illustrated, $9^1/_4$ by 6 inches, linen, $3.85. (ESL.)

This is a text on maps and their uses in field operations in war and peace. It is not concerned with the making and production of maps, nor does it cover the whole subject of topography. The first 12 chapters deal with general considerations such as scales, relief, and co-ordinates; the last four chapters cover briefly aerial photography, tactical topography, maps and logistics, and military geography. Numerou[s] tables of pertinent data are appended fo[r] reference use.

Rifles and Machine Guns. By M. M[.] Johnson. William Morrow and Company[,] New York, N. Y., 1944. 390 pages, illus[-]trated, $9^1/_2$ by 6 inches, cloth, $5. (ESL.)

Modern small arms here are analyze[d] from the practical viewpoint of use. Th[e] book describes all the important Unite[d] States and foreign weapons of the period o[f] World War II from the rifle and pistol t[o] the aircraft machine gun, covering thei[r] development, operation, loading, firing, an[d] disassembling and giving data on thei[r] ammunition, stoppages, accuracy, and em[-]ployment. Line drawings and photograph[s] illustrate the text.

Nonferrous Metals. (Postwar Buildin[g] Studies Number 13.) By a committee con[-]vened by The British Non-Ferrous Metal[s] Research Association, His Majesty's Sta[-]tionery Office, London, England, 1944[.] 72 pages, tables $9^1/_2$ by $6^1/_4$ inches, paper[,] 1*s*; obtainable from British Informatio[n] Services, 30 Rockefeller Plaza, New York[,] N. Y., 35 cents. (ESL.)

This report provides a practical review o[f] the uses of nonferrous metals in buildin[g] construction. After the general character[-]istics of these metals are described, thei[r] resistance to corrosion, mechanical proper[-]ties, and the methods of working and joinin[g] them are considered. The report discusse[s] the suitability of each for special uses, suc[h] as pipes, tanks, roofing, and fittings. Finally[,] the recommendations are summarized.

PAMPHLETS • • • •

Postwar Exportation of Capital Goods t[o] Nonindustrialized Areas of the World. B[y] George H. Houston. Machinery and Allie[d] Products Institute, 221 North La Sall[e] Street, Chicago, Ill., 16 pages.

The Steel Castings Industry. Steel Found[-]ers Society of America, 920 Midland Build[-]ing, Cleveland, Ohio, unpaged, no charge.

Production Management. Albert Ramon[d] and Associates, Inc., 6300 Chrysler Building[,] New York 17, N. Y., 40 pages.

The Future of American Science. B[y] Kirtley F. Mather, Harry Grundfest, an[d] Melber Phillips. United Office and Pro[-]fessional Workers of American, CIO, 186[0] Broadway, New York 23, N. Y., 19 pages[,] $1.50 per hundred, two cents each.

Problems of Mobilization and Reconver[-]sion, First Report. By the Director of Wa[r] Mobilization and Reconversion, Washing[-]ton, D. C., 58 pages.

The Early Years. The American Petroleu[m] Institute, 50 West 50th Street, New York 2[0,] N. Y., unpaged.

Future Financial Problems of Conversio[n] in the Aircraft Industry. By Tom Lille[y] and L. Laverne Horton. Harvard Busine[ss] School, Soldiers Field, Boston 63, Mass[.,] 49 pages, $1.50.

Fundamentals of Industrial Electronic[s]. By G. M. Chute. General Electric Com[-]pany, Schenectady, N. Y., 40 pages.